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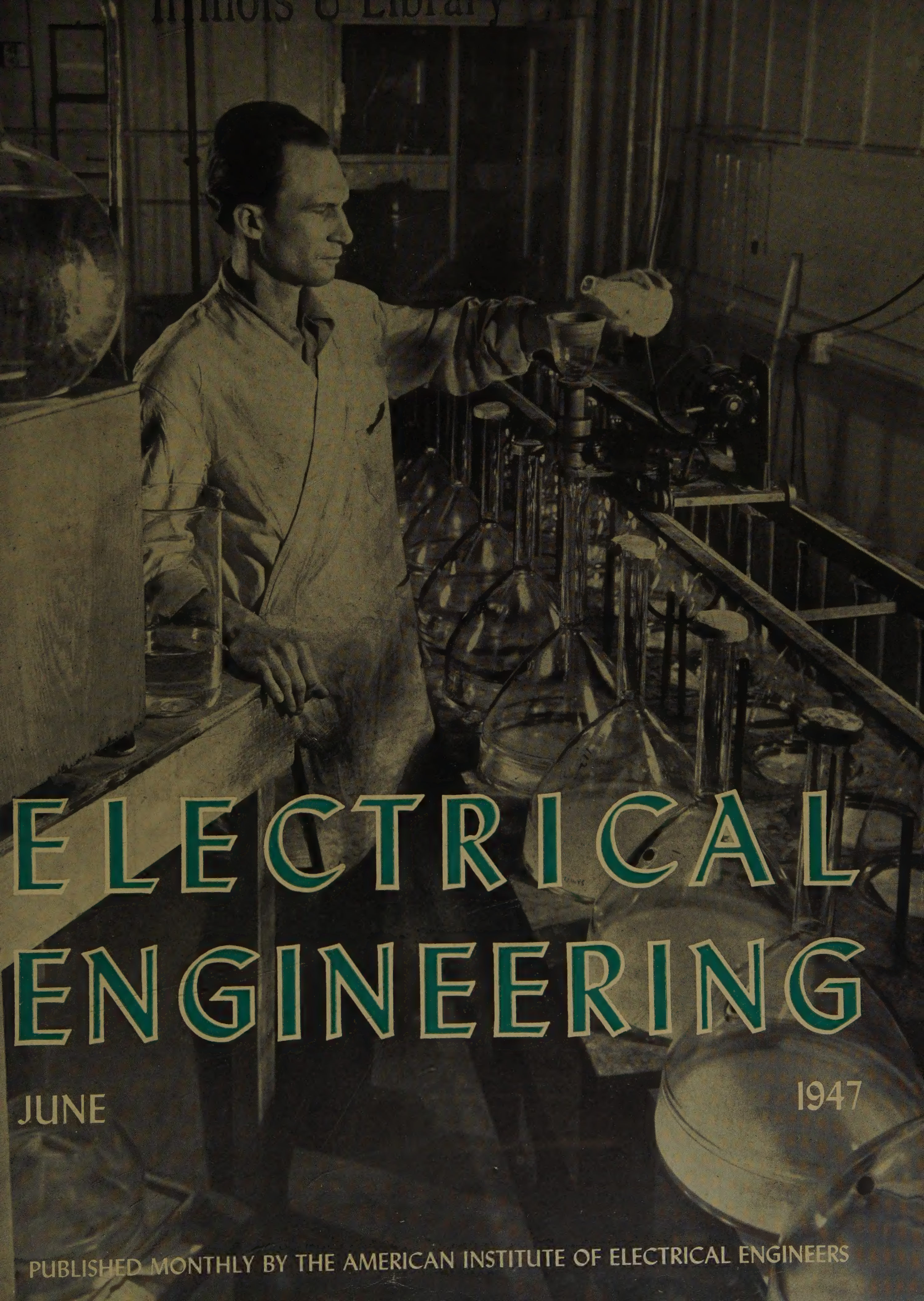

ELECTRICAL ENGINEERING

JUNE 1947

PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

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The Electrical Engineer

EVERETT S. LEE
FELLOW AIEE

The life of Thomas A. Edison, whose 100th anniversary is being observed this year, truly embodies the spirit of "The Electrical Engineer" for his contributions have stimulated almost every phase of electrical activity. To men such as Edison and his cofounders of the AIEE, to men whose accomplishments have been deemed worthy of recognition, and to every electrical engineer who simply serves faithfully, the world owes much of its comfort, its efficiency, and its well-being.

THIS year we celebrate the 100th anniversary of the birth of Thomas A. Edison. It is well that we do so, that we pause for a moment in the midst of our busy lives to observe this centennial of a great man, and, so inspired, to consider the values of human attainment, and to chart our future course in the light of present needs.

As the subject of this anniversary article, I have chosen "The Electrical Engineer." And what more appropriate title could I choose when I find that the 1,097 inventions patented in the name of Edison cover nearly every phase of electrical activity in which the electrical engineer is engaged today, even unto opportunities as yet unrealized. These inventions include:

1868—The electric vote recorder, Edison's first patented invention.

1869–1873—Stock ticker and various telegraph systems.

1876—"Electric pen," forerunner of the mimeograph machine.

1877—Phonograph and carbon telephone transmitter.

1879—Incandescent electric lamp; and systems of distribution, regulation, and measurement of electric current.

1880—Magnetic ore separator.

1885—System for communicating by means of wireless induction telegraphy between moving trains and railway stations; also ship-to-shore system.

1891—Motion picture camera.

1896—Fluoroscope. (Edison did not patent this invention, but chose to leave it to public domain because of its universal need in medicine and surgery.)

1900—Nickel-iron-alkaline storage battery.

1907—Universal electric motor for operating dictating machines on alternating or direct current.

1913—Kinetophone for talking motion pictures.

1914—Electric safety lanterns for miners; telescribe, combining the telephone and the dictating phonograph, thus permitting the recording of both sides of telephone messages.

And there were other events in the life of the great inventor which were important in the field of science:

1875—Discovered "etheric force," a phenomenon which 12 years later was recognized as the result of electric waves in free space. The discovery is the foundation of wireless telegraphy.

1880—Started operation of the first passenger electric railway in the United States, at Menlo Park, N. J.

1882—Began operation of the first commercial central station for incandescent lighting in the United States, in the city of New York.

1883—Discovered the "Edison effect," fundamental principle on which the modern science of electronics rests. While experimenting with his electric lamp he found that an independent wire or plate, placed between the legs of the filament, acted as a valve to control the flow of current.

1931—When stricken with his final illness, Edison was pressing his investigation of the possibility of growing rubber in continental United States.

Truly, the electrical engineer sees himself completely recorded here.

With each of these accomplishments there is a story of adventure, one of 10 per cent inspiration and 90 per cent perspiration, as, I believe, Edison has said. In the inspiration is that gem, the idea which is the source of all that is new, and in the perspiration is the ability, together with the faith and the perseverance and the hard work and the ingenuity and the support that brings the idea into fulfillment for the use of mankind. The older electrical engineers know this well from experience. The younger electrical engineers will have to put it down as the way of life—there is no other way.

From all of these stories of adventure, I have selected one—that of the incandescent lamp. Days of trial, even in the face of statements that it could not be done, brought Edison and his pioneers to the morning of October 18, 1879. It was to be a hard day ahead, but one of achievement for Edison, as he and his associates mounted another filament, the best one he had from the sewing thread. Another day was required to drive the gases from the filament and to evacuate the globe to a millionth of an atmosphere, and then the globe was sealed. Finally it was ready to be put to the test.

On the evening of October 19, 1879, the terminals were connected to the bichromate battery. The men watched quietly as the delicate hair filament under the bulb became luminously golden throughout its length. Steadily it glowed like a fairy thing amid the jumbled

Essentially full text of an address presented at the Edison centennial meeting of the AIEE Philadelphia (Pa.) Section, February 10, 1947.

Everett S. Lee chief engineer, general engineering and consulting laboratory, General Electric Company, Schenectady, N. Y., is a past vice-president of AIEE.

paraphernalia of the workbench, a radiant, entrancing sight.

Nobody spoke for several minutes. They were accustomed to this—the life test of a developmental lamp. All that mattered now was, "How long would this lamp last?" It lasted until between one and two o'clock on the afternoon of October 21, 1879, when the little filament went black. It had burned for some 40 hours. Mr. Edison said, "If the lamp will burn 40 hours now, I know I can make it last a hundred."

So the incandescent lamp was born, and the great electric light and power industry of today began. It is to the glory and achievement of the electrical engineer that the report of this industry for the year 1946 reads as follows:*

Output = 223,334,000,000 kilowatt-hours
Capacity = 50,196,000 kw
New capacity = 361,172 kw
Energy sales = 191,000,000,000 kilowatt-hours
Revenue = $3,450,000,000
Customers = 36,100,000

When Edison opened his first power plant at 257 Pearl Street in New York, N. Y., September 4, 1882, electricity cost 25 cents a kilowatt-hour. This year, as we mark the 100th anniversary of the great inventor's birth, the average price of household electricity throughout the United States is only a small fraction of that amount.

Thanks to Edison's imagination and enterprise, and thanks to the courage and initiative of many men and women working under the American business system, the United States enjoys the most and the best electric service in the world. All our lives are richer, safer, more productive.

There are many stories from Edison's life which might be related to honor the various phases of the electrical industry, but I have chosen the story of the incandescent lamp because it was Edison's outstanding contribution contemporary with the founding of the American Institute of Electrical Engineers on May 13, 1884.

The names of the founders of the AIEE are synonymous with the early beginnings of all the branches of the electrical industry, the fields of electric light and power, communications, and electrical manufacturing, as well as the professors, the inventors, and the patent attorneys. Their names are recorded for us to see and to revere as we recognize that in those early days of technical accomplishment, in the midst of the confusion of patents and business, there was in the lives of those great men that universal urge for a forum where they could meet to tell to the world and to their associates the results of their attainments, to improve themselves in technical ability through meeting with their fellows, to provide standards of practice for the various branches of the industry, and to provide for the maintenance of a high professional standing among their members.

We in the electrical engineering profession owe these men much. They builded well. They exemplify completely that statement by John Ruskin:

> Therefore, let us think that as we build, we build forever. Let it not be for present delight, nor for present use alone. Let our work be such that our descendants will thank us for, and as we lay stone on stone, let us think that a time will come when these stones will be sacred because our hands have touched them and that men will say as they look upon the labor and the wrought substance of them, "See, this our fathers did for us."

Thus the establishment of the American Institute of Electrical Engineers was accomplished by these men, and thus they established the profession. I trust that each and every electrical engineer, as he looks upon the labor and the wrought substance of the Institute, says with the greatest of pride, "See, this our fathers did for us."

Since its founding in 1884 the Institute has grown to be a mighty force. Its members have continued to be builders. AIEE membership as of January 28, 1947, was 26,728, distributed over many fields, approximately as follows:

Field	Per Cent
Electric light and power	22
Consulting and large contracting	7
Communication	9
Electrical manufacturing	22.5
Industrial and transportation	13
Government	9
Professors and instructors	3.5
All others	14
Total	100
Students	26

AIEE members, through their contributions, have helped to advance the electrical industry until today it stands pre-eminent in the service of man.

These members, in 75 Sections and 32 Subsections throughout the United States, Canada, and Mexico, and in 60 foreign countries, together with electrical engineering students in 126 Student Branches in as many collegiate engineering schools, represent a vital, dynamic force, meeting regularly and enthusiastically to advance the theory and practice of electrical engineering and of the allied arts and sciences, and to maintain a high professional standard among AIEE members. We are proud of our Institute.

The contributions of AIEE members to the advancement of the profession by translating into practice the new ideas in every electrical field and activity represent the daily life of the electrical engineer as he serves mankind. These contributions range all the way from the very least to the very greatest. All have a place, an important place. To those whose contributions have been considered most outstanding, the Edison Medal has been presented, the highest honor which the Institute can con-

* *Electrical World*, 43rd annual statistical issue, January 18, 1947.

fer. As we revere Edison in recognizing the outstanding value of his contributions to all of us and to all of our fellow men—so we recognize that these men have contributed to bring to us and to untold others the opportunities for a more fruitful life.

We are proud of the accomplishments of these engineers throughout the years, from the days of Edison to the present time. Were it not for our Institute we would not have had the opportunity to honor them. We are proud of our Institute.

To this point I have discussed only the electrical engineer, though many readers already have thought of the outstanding contributions of other engineers to these accomplishments. When the Institute was founded in 1884, there were then in existence the American Society of Civil Engineers founded in 1852; the American Institute of Mining and Metallurgical Engineers founded in 1871; and the American Society of Mechanical Engineers founded in 1880. The AIEE is the youngest of these four Founder Societies, though today it is the largest in membership.

Subsequently, in 1908, the American Institute of Chemical Engineers was founded, thus completing the five fundamental engineering societies.

These societies also have grown to be strong, active, engineering organizations, and if the story of the electric power and light industry were being told by a civil engineer he would tell of the building of the great powerhouses and of the great dams and of the transmission lines. If it were being told by a mechanical engineer he would tell of all the boilers and of the turbines and of the engines, and all the many phases of power generation; and if by a mining engineer, he would tell of the mining of the coal, and of the oil, and of the new metallurgy. If the story were being told by a chemical engineer, he would tell of the engineering of the chemical processes of great power and magnitude. Each has made an outstanding contribution to this outstanding industry.

So it is in all the branches of the electrical industry; other engineers have contributed most effectively. And, similarly, so has the electrical engineer made outstanding contributions to the various branches of other industries.

Other engineers also have brought new societies into existence to advance the arts and sciences and to maintain a high professional standing among their particular members. There are many of these. One particularly should be mentioned, the Institute of Radio Engineers. Founded in 1912 with fewer than 50 members, the membership today is approximately 18,000 from every corner of the globe. Wherever the electrical engineer is mentioned, so must the radio engineer be included for his outstanding contributions to that branch of the industry which again, emanating from the wonderful insight of Edison into nature, has been carried to such glorious accomplishment by those who have followed him.

Thus, with the years, a situation has been fostered within the engineering profession wherein each group that can support an engineering society does so. As a result the engineering society setup is characterized as being everything from strength to chaos.

I am one of those who believe that the situation is one of strength. Through the engineering society of his choice, the young engineer has the opportunity, even while he is in his collegiate training period, to become a member of a Student Branch, to become a corporate member of his society upon receiving his engineering degree and acquiring experience, and to continue throughout his engineering life to advance his profession, to make his engineering contributions known, and to profit and advance himself by hearing of the contributions of others.

When the young engineer obtains his license to practice engineering, the opportunity for further participation in engineering society activity is available to him. And as he advances more, the more specialized engineering societies provide additional opportunity for his participation.

But this all seems very formidable and complex to the younger engineer. He feels that with it all there is lacking the over-all engineering professional society which he sees so prominent in the medical and legal professions. Thus he may not join any engineering society. This is a great pity—and I suppose that somewhere we of the AIEE are to blame. Just recently I learned of a group of outstanding engineers, some 1,550 strong, of whom only 440 were members of a national engineering society. It is hard to believe that 1,100 engineers in one group, good and true, would not feel the urge to join with their fellows, yet it is so. From best estimates there are from 55,000 to 60,000 individuals in the United States eligible for admission to the AIEE. We thus can number as members only about one half of those eligible. While this is good—there is still opportunity for much greater participation.

Our engineering society setup leaves much to the individual and many believe that this is as it should be for it is in synchronism with the initiative and freedom which characterizes the engineer. The very foundation and strength of our attainments in our country is initiative and freedom. Just the mention of American battle grounds, of Trenton and Monmouth and Valley Forge, brings the ring of freedom to our ears, freedom springing from initiative and resulting from ability, ingenuity, hard work, strength, perseverance, faith, all to the end that our fellow men have been served that their lives will be the better. The price has been high. These virtues we hold so dear are not given to us—they are fought for. The things we have which make life happy are not given to us—they are worked for. The fight has been hard—the work has been hard. But I do not believe that there is any other way.

So I say to the young engineer, join the society of your choice, work for it, and as you advance you will dis-

cover opportunities to which you can apply yourself to make your society even better. It is far better to be inside and pitching, than it is to be on the outside and critical.

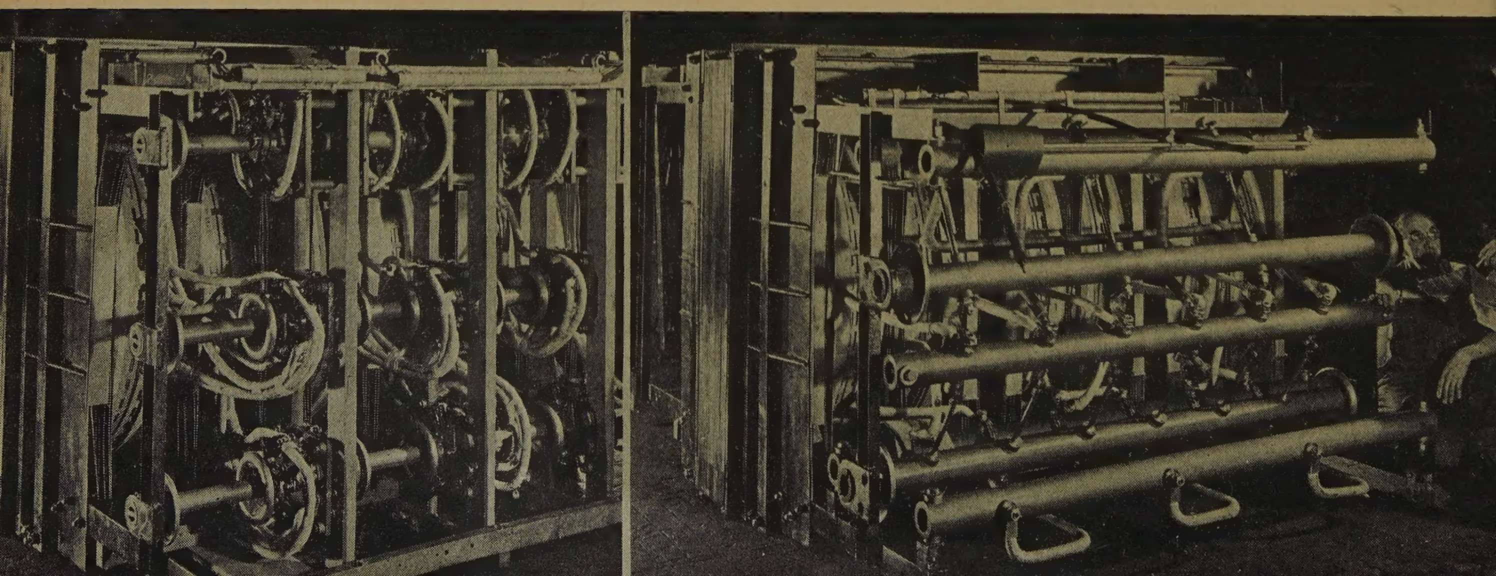
With all of the strength of our individual engineering societies, I, nevertheless, am one of many who would like to see the establishment of an over-all engineering association to keep nationally prominent the contributions of the engineering profession. I am convinced that much of value would emanate from such an arrangement. I would call it the American Engineers Association, and it would be formed from the present societies. These societies would maintain their present organizations, but would contribute representation and funds to the association. The association would progress at a national level those subjects upon which agreement would be arrived at to secure for the engineer a more general recognition of his contribution and a more definite recognition of his professional status. I know this is not a new thought, but I know that its attainment would inspire new thoughts, and I sincerely believe that they would result in great good. Moreover, with our present national regard, it is wrong that the engineer, whose contribution moves into every phase of life activity, should not be recognized more appropriately.

Everything we have comes from the engineer. This paper from which you are reading, the press on which it was printed, the train which brought it, all came from the engineer. The house in which we live, the furnishings, the lights, the street outside, the buildings of the city, the telephones, the telegraph, the movies, all came from the engineer. The farm equipment on the farms, the roads, the automobile, the radio, the airplane, the electric power for home and industry, all came from the engineer; and by engineer I mean scientist and engineer. The tanks, guns, airplanes, ships, and ammunition of our war production all came from the engineer. The opportunities for all peoples to work have come from the engineer. The opportunities for all peoples to work in the future will come from the engineer.

On February 11, 1947, the nation and the world celebrated the 100th birthday of a great man, Thomas A. Edison. I have used his contributions to illustrate the scope of the activities of the electrical engineer. I have depicted the formation of the American Institute of Electrical Engineers, contemporary with Edison and with the beginnings of the great electrical industry. I have brought you a picture of the engineering profession with its many strong, active, engineering societies for the progression of the arts and sciences and the maintenance of a high professional standard among its members. I have pleaded with the younger engineers to be loyal to their engineering societies and to stay with them throughout their engineering life. I have stated again the need for an over-all engineering profession group to give rightful acclaim and status and position to the engineer by virtue of his contributions. I do this recognizing that in the engineering profession we have a record of accomplishment and service that shines as brilliantly as the lighting which has grown from that first filament that lived some 40 hours—and that just as was Edison's life a life of service, so does every engineer serve. And just so long as he serves and serves righteously, mankind will prosper.

High Voltage Mobile Substation

View of the core and coils of one of the highest voltage mobile substations ever built, constructed by the Allis-Chalmers Manufacturing Company for the United States Department of Interior, Bonneville, Oreg. Tap changing mechanism provides low voltages from 2.4 kv to 13.8 kv from a 31-kv to 110-kv 3-phase line. Delta and Y connections are provided together with 4 plus $2^1/_2$ and 6 minus $2^1/_2$ per cent voltage taps. The forced-oil-cooled transformer together with high and low voltage switchgear will be trailer-mounted to provide a 2,500-kva emergency tie-in substation for a large West coast network. At the left is shown the low voltage side and at the right the high voltage side of the horizontally mounted unit



Electrostatic Sources of Electric Power

JOHN G. TRUMP
ASSOCIATE AIEE

Because they are inherent in the structure of matter, electrostatic phenomena were noted and recorded even in ancient times. However, neglect of their practical application to the generation and utilization of electric power has resulted from the slow development of insulating media. From this viewpoint, the author examines the voltage-insulating qualities of compressed gases and high vacuum and the prospects for obtaining compact machinery so insulated.

IT MAY BE SAID that the most direct and powerful forces in nature are the electrostatic forces resulting from the presence of electric charge. Within the atom it is the nuclear charge which distinguishes one element from another and which resists the penetration and disintegration of the nucleus by impinging charged particles. The number and disposition of the electrons swarming about the nuclear charge govern the relations of one atom with another and, in the final analysis, determine the physical strength and other properties of matter. Nor are the conspicuous effects of electric charge confined to atomic dimensions. In the experimental procedures of modern physics, electrostatic forces and principles often are invoked for the deflection of moving charged particles and for their acceleration to high energies. Electrostatics is involved in the multielement vacuum tube, which is the basis of all electronic communication and control, as well as in some methods for the generation and storage of electric energy.

HISTORICAL DEVELOPMENT

Electrostatic phenomena were the first in the history of electrical science to be observed and subjected to quantitative investigation. As early as the seventh century B. C., Thales of Miletus, one of the "seven wise men" of early Greece, knew that amber, when rubbed, had the property of attracting light objects. Three centuries later, Theophrastus, in his treatise on gems, mentioned another mineral which becomes electrified by friction. By the 17th and 18th centuries electrostatic phenomena, including the attraction and repulsion of electric charges, had become of absorbing interest in physics. Von Guericke of Magdeburg, who performed many original experiments on the effects of vacuum, produced the first generator of electricity by holding his hand against a rotating sphere of sulphur. Isaac Newton and others experimented and improved such generators; Franklin speculated on the nature of "electric fire" and correctly identified natural lightning as a discharge of electricity.

The first quantitative measurements in electrostatics were made by Cavendish at Cambridge University toward the end of the 18th century. Cavendish studied the capacitance of various electrode arrangements and measured the specific inductive capacity of different substances. Anticipating the work of Coulomb and Faraday, he showed that electric charge resides on the surface of conductors and proved that the force between

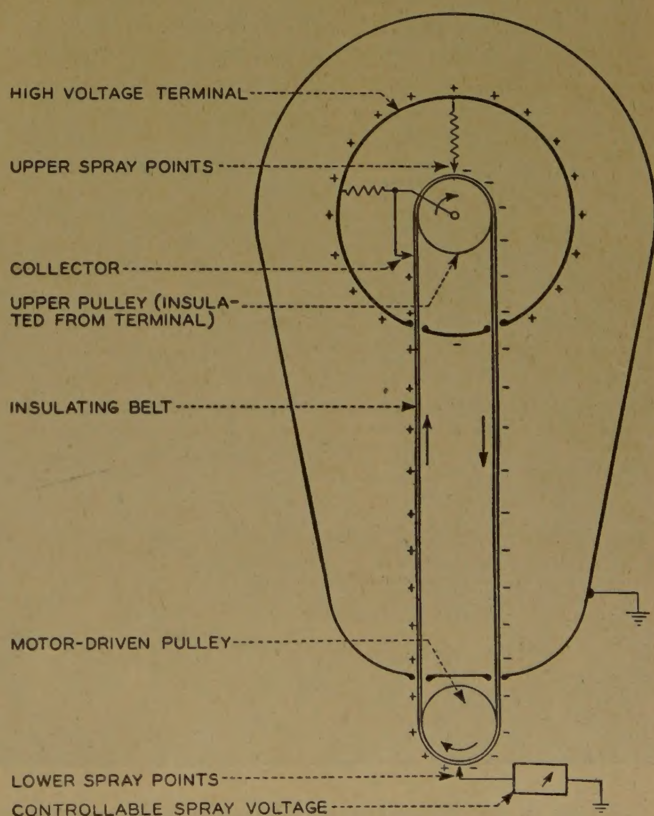


Figure 1. Diagram of Van de Graaff electrostatic belt generator

Full text of a paper presented at the conference on energy sources held January 29, 1947, during the AIEE winter meeting, New York, N. Y.

The author specifically acknowledges his association with Doctor R. J. Van de Graaff in developing knowledge of his subject and the help of his associates at Massachusetts Institute of Technology, particularly that of R. W. Cloud.

John G. Trump is associate professor of electrical engineering at Massachusetts Institute of Technology, Cambridge, Mass.

charged bodies is inversely proportional to the square of the distance d between them. In 1785 Coulomb, using a torsion balance of his own design, showed that the force f between charges q_1 and q_2 is given by

$$f=\frac{q_1q_2}{d^2}$$

Recent electron-scattering experiments have demonstrated that Coulomb's law applies equally well to subatomic dimensions. A high-energy electron projected into close approach with an atomic nucleus obeys this relation quite exactly;[1] most of the energy of nuclear fission is released through the coulomb forces of repulsion exerted between the separating fragments.[2]

Faraday, who with Oersted and Henry made the first important discoveries in the field of electromagnetism, did much to extend the knowledge of static electricity along the directions investigated half a century earlier by Cavendish. Faraday proposed the well-known symbolism of "lines of force" to replace the theory of "action at a distance" between electric charges or magnetic poles. With the passing of another half century, Maxwell was translating Faraday's theories into the language of mathematics and laying the basis for the present electromagnetic theory.

The present era of atomic physics was introduced by the discovery of X rays in 1895 by Roentgen, followed closely by Becquerel's discovery of natural radioactivity in 1896 and the identification of the electron by J. J. Thompson in 1897. These discoveries revealed the electrical nature of the elementary particles and provided an insight into the molecular and atomic structure of matter. Rutherford, in clarifying the structure of the atomic nucleus, showed that this citadel of mass and energy was protected by a high-potential barrier from all positive particles save those of sufficient energy. The increasing need in experimental nuclear physics for more copious and controllable sources of such high energy particles rekindled the interest in electrostatic methods of generating high electric potentials, and is leading to a more significant place for electrostatics in modern science and engineering.

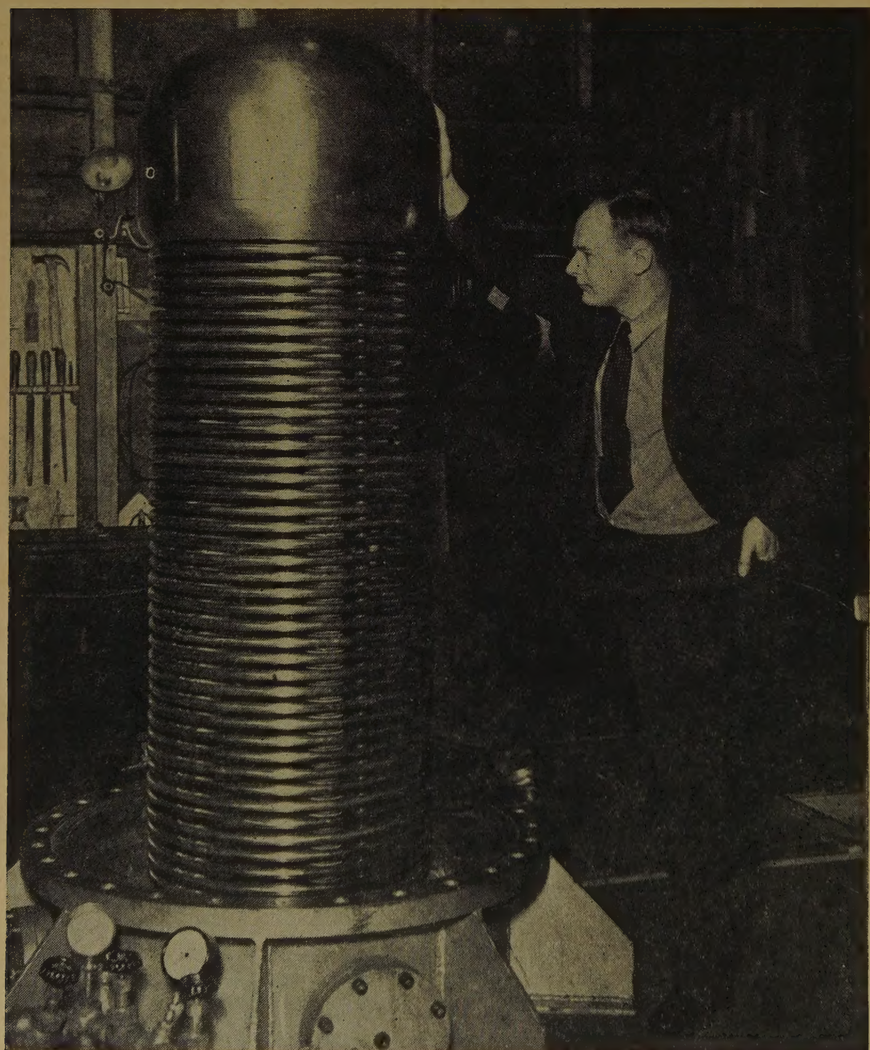


Figure 2. A 1.25-million-volt electrostatic belt generator with tank removed

Insulated by air at 10 atmospheres pressure, this generator has been in use at the Massachusetts General Hospital since 1940 for the production of X rays for deep cancer therapy

ELECTROSTATICS AND ELECTROMAGNETICS

A conductor carrying a current is surrounded by both an electric and a magnetic field. In general, the magnetic field depends on the current strength, and the electric field depends on the voltage of the conductor relative to its surroundings. An electromagnetic force is produced by the interaction of two magnetic fields, which in turn require the motion of electric charge. An electrostatic force involves an electric field, which is produced merely by the presence of electric charge. Electromagnetic sources of electric power are, therefore, basically high-current devices, whereas electrostatic sources are inherently high-voltage devices. Although the maintenance of an electrostatic force is evidently a simpler and more efficient process in nature than the maintenance of a magnetic force, electromagnetics has enjoyed overwhelming advantage in the relative ease with which large currents can be conducted through

metals and in the availability of materials with high magnetic permeability. In contrast, only indifferently good media, such as atmospheric air, have been available in the past for the insulation of high voltages in electrostatics, and the better insulating materials are without exception characterized by low dielectric constants. As a result, the application of magnetic forces and principles in electric power engineering has met with a high degree of success, while the application of electrostatic forces and principles to power engineering has been extremely limited up to the present time. Since the turn of the present century, however, electrostatics has become of increasing importance in high-voltage low-power applications, particularly for the production of homogeneous streams of high-energy charged particles. In this field electrostatics has exhibited the advantages of directness and simplicity over other methods for the attainment of the high constant potentials required in such accelerators. But just what are the principles involved in the electrostatic generation of electric power and what are the factors which may extend the utility of such generators into the realm of high-voltage and high-power devices?

VAN DE GRAAFF ELECTROSTATIC BELT GENERATOR

For the production of high voltages at relatively low power, the frictional and influence machines of the last century have been replaced by Van de Graaff electrostatic generators. Capable of developing constant potentials up to 10 million volts and steady currents up to several milliamperes, these generators are used for the acceleration of charged particles to high energies for nuclear research, for the production of penetrating X rays for therapy and industrial radiography, and for high-voltage engineering studies.

Operating Principles. As indicated in Figure 1, the Van de Graaff generator[3] consists of a well-rounded high-voltage terminal suitably supported above ground and a rapidly moving insulating belt which continuously transfers charge between ground and terminal. An important consideration in the operation of these generators is that the charging of the belt at its ground end and the removal of the charge at the terminal are performed within the field-free regions below the ground plane and inside the high-voltage terminal. Thus, these charging and charge-removing functions remain independent of the terminal voltage.

The maximum voltage which can be attained by the terminal depends only on its ability to insulate. As charge is brought to the terminal, its voltage rises at the rate

$$\frac{dV}{dt}=\frac{i}{C}$$

where i is the net current to the terminal and C is its capacitance to ground. This rate is usually about 1

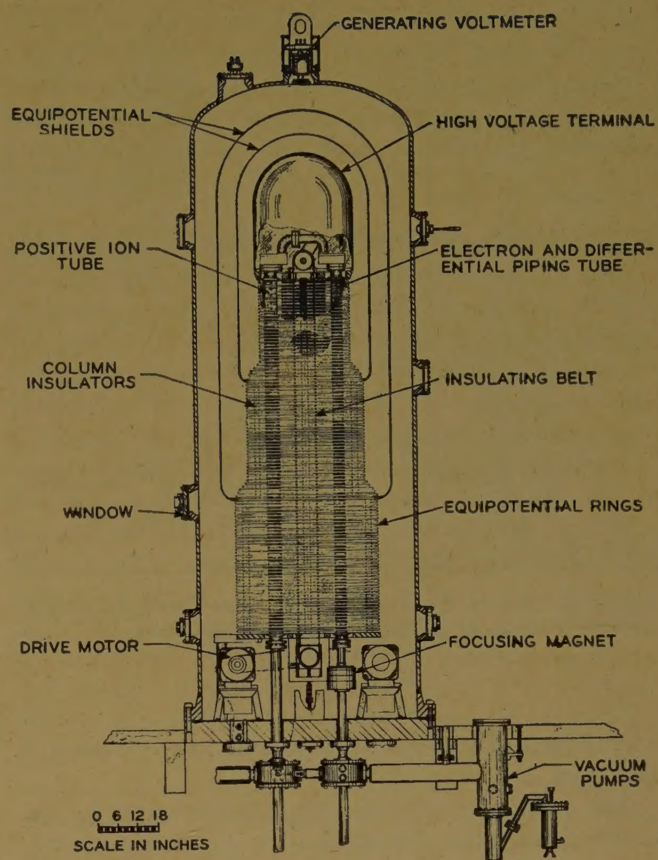


Figure 3. A 5-million-volt electrostatic accelerator now being completed at the Massachusetts Institute of Technology for precision studies of nuclear reactions

million volts per second. At any instant the voltage of the generator is $V=Q/C$, where Q is the charge on the terminal. The generator operates at that equilibrium voltage at which the current transferred by the belt is equal to the load current; this equilibrium voltage may be varied over a wide range by controlling either the belt or load currents.

The High-Voltage Terminal. The ideal terminal would be an isolated conducting sphere. Such a sphere could maintain a voltage Gr, where G is the maximum gradient which can be insulated in the dielectric surrounding the sphere, and r is the radius. However, a practical terminal must be supported physically from ground, must be supplied with electric charge, and usually is connected to a load such as an acceleration tube. For these reasons, the terminal shape is modified to provide a definite and uniformly controlled electric field in the region of the supporting column, belt, and tube. The column may be constructed of a series of conducting members separated by insulating supports. Resistors or corona are used to divide the terminal voltage uniformly between these equipotential planes. The charge-conveyor belt and acceleration tube pass within this column and benefit by the uniform distribution of potential. A typical terminal and column

and 6,000 feet per minute. As indicated in Figure 1, electric charge is sprayed on the belt at the grounded end from a row of corona points extending across the width of the belt and directed at the pulley. A small voltage maintained between these points and the pulley results in ionization of the gas at the points and causes the transfer of electric charge toward the pulley. This charge is intercepted by the intervening insulating belt and physically carried to the terminal. The charge sprayed on the belt in this manner may be controlled by regulating the corona-spray voltage. The generated electric power is equal to the mechanical work done in moving the electric charge to terminal potential.

Within the high-voltage terminal the belt charge may be removed from the ascending belt by a similar corona point collector and connected to the terminal. In this arrangement only the upward belt run is utilized. More generally, the arriving belt charge is employed first to bring the upper pulley to a higher potential than that of the terminal. This enables an upper corona spray point to transfer electric charge of the opposite sign to the moving belt, which carries it away. A resistance network between the upper pulley and terminal can be adjusted so that the current carried on the downward run of belt corresponds approximately to the current on the ascending run. Thus, both belt runs can be effective in transferring electric charge continuously between ground and high-voltage terminal.

The current capacity of an electrostatic generator depends upon the width and speed of the belt and upon the dielectric strength of the gaseous medium in which it operates. For air at atmospheric pressure, the maximum charge density is 5.3×10^{-9} coulomb per square centimeter of belt surface. This is based on the assumption that the electric field due to the belt charge is uniform and normal to the belt in both directions and that the permissible field intensity in air is 30 kv per centimeter. Actually, about half of this maximum charge density can be attained; thus the two runs of single belt 1 foot wide and traveling in atmospheric air at 6,000 feet per minute can deliver nearly 0.5 milliampere.

The charge on the belt surface itself may be the cause of insulation difficulties, unless its electric field is controlled and confined to the region closely adjacent to the belt surface. This can be accomplished by means of spaced conducting rods connected to the column sections and mounted closely parallel to each side of the belt. The electric field due to belt charge now can extend only to the field control rods, and each belt run has become electrically independent of its neighbor. Figure 4 shows such a field control arrangement with the electric field plotted for the cases

1. With belt uncharged and voltage applied between column sections.

2. With belt charged but column grounded.

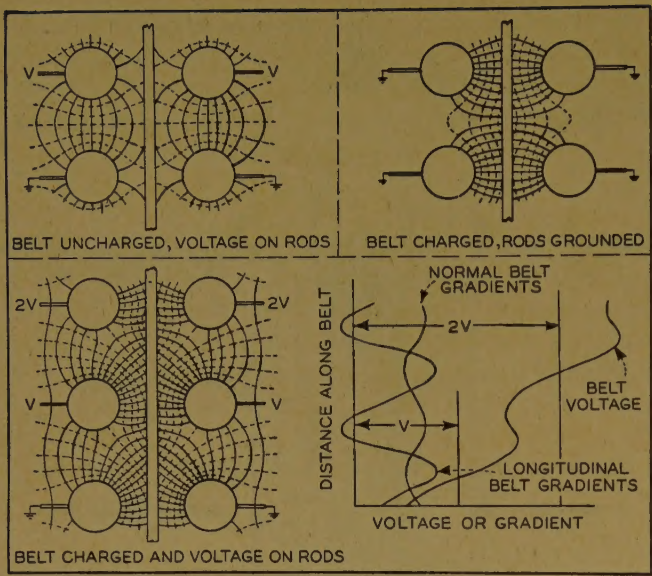


Figure 4. Plot of the electric field around the field control rods of an electrostatic belt generator

arrangement[4] for an electrostatic generator is illustrated in Figure 2.

The maximum terminal voltage is influenced by the terminal and tank geometries. For concentric spheres, for example, the maximum voltage is obtained when the outer diameter is twice that of the inner terminal. This assumes that breakdown ensues when a limiting electric gradient is reached. In generators of higher voltage rating it is often desirable to control the electric field around the terminal by means of intermediate metallic equipotential shields. These shields derive their potential by being connected to the appropriate level of the generator column. The optimum voltage can be insulated if the diameters of these electrodes, considered as concentric cylinders, obey the relation

$$\frac{r_1}{r_2} = \frac{r_2}{r_3} = \frac{r_{n-1}}{r_n}$$

where $r_1, r_2 \ldots . r_n$ represent the radii of the electrode surfaces beginning at the terminal. Such intermediate shields around the terminal are illustrated in the diagram of the 5-million-volt generator of Figure 3. The effect of these shields is to render the gradient more uniform throughout the gap from terminal to tank and to remove any restriction on the relative size of the terminal.

The Charge-Conveyer System. While oil streams, charged vapors, and solid particles could be employed, the most effective charge-conveyers for both air and compressed-gas insulated electrostatic generators have been flat endless belts of insulating material. These belts usually are made of multiply rubber fabric and travel between the ground plane and the interior of the high-voltage terminal at constant speeds between 4,000

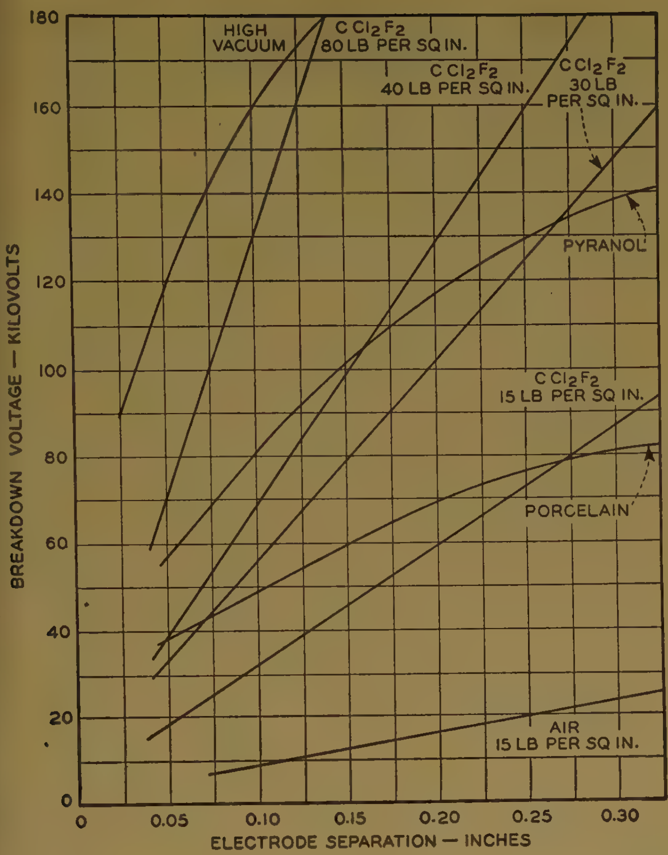


Figure 5. D-c breakdown across typical solid, liquid, gaseous, and high-vacuum insulation, uniform electric field

The lower field plot shows the superposition of these two cases and represents the field picture along the belt under full voltage and current operation. As the gradient normal to the belt surface in a pressure-insulated belt generator may be as high as 100 kv per centimeter, the importance of the closely spaced rods in limiting the potential between the charged belt and the column section at that level is evident. The field control rods on each side of the belt also tend to divide the belt lengthwise into a series of short sections with controlled potential applied to each. With this arrangement, an increase in the dielectric strength of the surrounding gaseous medium results in a fairly proportionate increase in current capacity and voltage strength along the belt.

INSULATION FOR ELECTROSTATIC GENERATORS

The two insulating media of greatest importance in electrostatic engineering are compressed gases and high vacuum. A comparison of the performance of solid, liquid, gaseous, and high-vacuum insulation in a uniform field is shown in Figure 5. For constant voltages below about 10 kv, vacuum is superior to all other insulating media; at such voltages cathode gradients of several million volts per centimeter and anode gradients at least ten times higher can be supported. At higher voltages, however, compressed gases are superior to high vacuum in the present state of the development; as the voltage strength between gas-immersed electrodes continues to increase nearly linearly with electrode spacing. Consequently, compressed gases now are used for the insulation of the high voltages produced by electrostatic belt generators.

Compressed-Gas Insulation. It was stated by Paschen, and it follows from Townsend's and subsequent analyses,[5] that for a given gas in a uniform field the sparking voltage is a function of the product of the interelectrode gap and the gas pressure. The more general similarity law explains that the sparking potential of a gas remains unchanged, if the physical dimensions of the electrodes and gap are reduced in the same ratio that the pressure is increased. Knowledge of this dependence of dielectric strength on gas pressure led to the early use of highly compressed air, nitrogen, and carbon dioxide for the insulation of electrostatic belt generators. Figure 6 shows the most compact electrostatic belt generator thus far developed. This tank-enclosed generator operates at a steady d-c potential of 2 million volts for the production of medical and industrial X rays and is insulated by air or nitrogen at a pressure of 27 atmospheres. The 16-inch diameter terminal is spaced 7 inches from the tank walls and, at full voltage, has an electric gradient at its surface of 400 kv per inch. At atmospheric pressure this generator can insulate only about 250 kv. The 24-inch-long column has a normal operating gradient of 1 million volts per foot and contains a 6-inch-wide belt which delivers a current at full voltage of 500 microamperes.

Since the investigations of Natterer in 1889, it has been known that certain compounds in the gaseous state, particularly those which contain chlorine, fluorine, and other negative atoms, have a higher insulating strength than the common gases at the same pressure. For example, the vapor pressure of carbon tetrachloride (CCl_4) adds a 20 per cent increase to the dielectric strength of air at atmospheric pressure, though this vapor pressure is but 2 pounds per square inch absolute at normal temperature. Of the many compounds which have been investigated, Freon (CCl_2F_2) and sulphur hexafluoride (SF_6) have been found to be particularly promising as insulating media.[6,7] Both of these gases can insulate the same voltage as air or nitrogen at but one third the pressure. Sulphur hexafluoride is the superior gas, both because of its greater chemical stability and because its equilibrium pressure at normal temperature is 350 pounds per square inch as contrasted with 85 pounds per square inch for Freon.[8]

Unlike electromagnetic devices, the voltage rating of electrostatic generators can be increased merely by improving the dielectric strength of the surrounding medium. An increase in voltage rating of a transformer, for example, requires increases in the number of secondary turns and in the insulation of the high-voltage wind-

ing. The reactive power requirement increases very rapidly with voltage and, in very high-voltage transformers becomes an important limitation. But in an electrostatic generator, the equilibrium voltage is raised merely by the addition of electric charge, the only practical limit to this voltage being the insulation strength of the terminal to ground. For an electrostatic generator of given voltage and current rating, an increase in the dielectric strength of the gaseous medium permits a nearly proportionate reduction of the physical dimensions of the apparatus. Thus, an improvement in dielectric strength is reflected in the limit as the cube in reduced volume of the generator.

Flashover of Solids in Compressed Gas and High Vacuum. High-voltage apparatus insulated by compressed gas or high vacuum requires solid insulation for the physical support of the electrodes. Flashover of solid insulation therefore may occur between the equipotential planes of the generator column, along the electrically charged belt, and along the inner and outer surfaces of the acceleration tube. Even in a uniform field the flashover voltage of such solid insulation, whether in compressed gas or in vacuum, is ordinarily considerably lower than for the gas-filled gap of equal length.

The flashover strength of the solid insulator can be brought close to that of the gas[9] or the vacuum in which it is immersed by proper selection of material and shaping of its surface. Figure 7 shows a small section of an acceleration tube in which the solid insulating material was Vycor, a 96 per cent silica glass. Tube sections were divided by means of conducting diaphragms in a manner typical of multistage acceleration tubes. On the outside the tube was surrounded by compressed air at 27 atmospheres, while on the inside high vacuum was maintained. More than 80 kv direct current could be insulated reliably between adjacent diaphragms 1 centimeter apart, and a total voltage of 450 kv was insulated across the total tube length of $2^1/_4$ inches. Studies of the flashover of solid insulator surfaces immersed in compressed gases and in high vacuum have shown the strong dependence of flashover performance on the material of the insulator and have indicated the benefits of surface contouring, good electrode contact conditions, and freedom from surface contamination.

Figure 6. A 2.0-million-volt electrostatic X-ray generator with tank and X-ray tube removed

Voltage Breakdown in High Vacuum. Vacuum insulation, which is essential for the acceleration of charged particles within an acceleration tube, ultimately may become of importance as the insulating medium for high-voltage electrostatic generators. The present performance of vacuum insulation under constant voltages and with small electrodes is indicated by Figure 8. This shows that, whereas cathode gradients of several million volts per centimeter can be insulated at voltages below 10 kv, gradients of only about 1 million volts per centimeter can be insulated at 100 kv, and the cathode gradient continues to diminish with further increase in voltage. High-voltage studies[10] have been started in recent years on the mechanism of high-voltage breakdown in vacuum. It has become clear that breakdown proceeds from an interchange of charged particles and photons between cathode and anode, this interchange being dependent primarily on the energy of the particles and only secondarily on the field strength at the electrode surfaces. Consider the uniform field between two parallel metallic electrodes in high vacuum, with constant voltage applied. An electron proceeding from

the cathode will impinge upon the anode with energy equal to the gap voltage. The impact of the electron has some probability of causing emission of a positive ion and photon. Such a positive ion, accelerated by the voltage, will return to the cathode with the probability of causing secondary electron emission. Some of the photons likewise will return to cause photoelectric emission from the cathode. The escape of these secondary particles is assisted by the electric field at the electrode surfaces. Instability and breakdown ensue when the gap conditions permit a cumulative increase in this interelectrode current.

As the electrode surfaces in high vacuum may be rendered free of contamination, and the electric field configuration can be known accurately, these breakdown mechanisms may be studied more quantitatively than is possible in investigations involving material insulating media. Secondary and photoelectric emission depends on such factors as the electrode material, the use of insulating surface films and of grids, and the proper conditioning of the electrode surfaces. It appears entirely possible that vacuum insulation may be brought by such studies to a point where gradients of several million volts per centimeter can be insulated even at intermediate or high voltages.

Figure 7. Test section of acceleration tube

With high vacuum inside and air at 27 atmospheres outside, 450 kv was insulated across the $2^1/_4$-inch tube length

VACUUM-INSULATED ELECTROSTATIC MACHINERY

The realization of such superior insulating properties in high vacuum would make practicable a new type of electrostatic power equipment consisting essentially of variable capacitors formed by interleaving rotating metallic plates.[11] Forces which may be involved in such vacuum-insulated electrostatic generators are illustrated by the following example: Consider two metallic plates of 100 square inches area which are parallel and insulated from each other. If a constant voltage were applied to produce an electric field of 300 volts per centimeter between them, the electrostatic force of attraction would be about 0.0005 pound. If the active gradient were increased to 30,000 volts per centimeter, which is the highest voltage that can be insulated in atmospheric air, the electrostatic force between the plates would have increased to little more than 0.5 pound. If these plates were immersed in high vacuum and the gradient increased to 3 million volts per centimeter, the electrostatic force would be about 5,700 pounds. This is the kind of force which would be utilized in the electrostatic generation and conversion of electric power.

General Principles. Vacuum-insulated motors and generators would be essentially variable capacitors connected across the power line, the stator and rotor of which are interleaving metallic plates. The general equation for the current flowing at any instant in a capacitor circuit, the capacitance and impressed voltage of which vary with time, is

$$i=C\frac{de}{dt}+e\frac{dC}{dt}$$

The power input to the circuit at any instant is

$$P=ei=Ce\frac{de}{dt}+e^2\frac{dc}{dt}$$

The first term in the right-hand member of this equation represents the power transfer between the outer circuit and the electrostatic field due to change in voltage and does not involve any transformation of electric to mechanical power. Half of the second term, or

$$P=\frac{e^2}{2}\frac{dC}{dt}$$

represents the mechanical work which must be done on or by the system at voltage e to cause its capacitance to change at the rate of dC/dt. The remaining half represents the rate at which the stored energy in the system at voltage e is changing because of the capacitance variation. If dC/dt is positive, then electric energy is being absorbed by the circuit, and mechanical energy is being delivered. If dC/dt is negative, then mechanical energy is being absorbed and electric energy delivered. These three equations or their equivalents are the basis of studies of the electrostatic machines.

A-C Synchronous Electrostatic Machine. An interesting a-c electrostatic machine consists of a simple variable capacitor of balanced construction upon which a periodic voltage e is impressed. Such a machine develops power as a motor when the positive intervals of dC/dt occur at the larger values of e, and the negative intervals when e

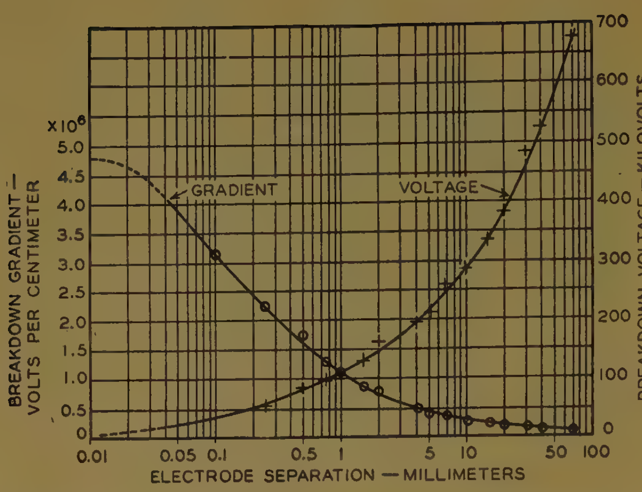


Figure 8. D-c breakdown voltages and gradients between a 1-inch steel ball and a 2-inch steel disk in high vacuum as a function of spacing

is small. The motor will run at a synchronous speed given by

$$n = 120\,\frac{f}{p}\ rpm$$

where f is the frequency of impressed voltage in cycles per second and p is the number of poles or the number of

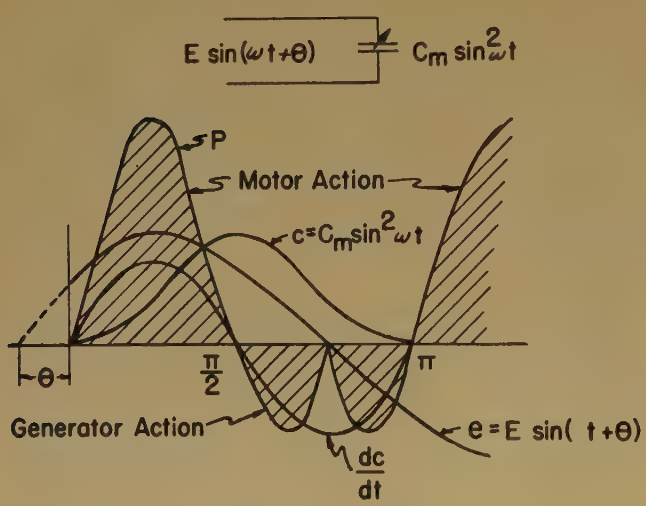


Figure 9. Circuit and phase relations of a synchronous electrostatic machine running as a motor

cycles of capacitance variation per revolution. It adjusts to increasing loads by changing its "power angle" in a manner analogous to the well-known electromagnetic synchronous motor. When maximum power angle is reached, further increase in load causes the motor to pull out of step. The schematic diagram and phase relations of voltage, capacitance, and power are shown in Figure 9. The same machine will develop power as a generator when driven synchronously to the line voltage and at such a phase angle that more generator than motor action is realized.

The time rate of capacitance variation of these electrostatic machines at constant synchronous speed must be of double line frequency and may be of any wave form from rectangular to sinusoidal. The latter is preferable because of the relative absence of harmonics. The average output power of such a machine is given by

$$P_a = \frac{E^2 \omega C_m}{4} \sin 2\theta$$

where E is the maximum line voltage, ω is the angular velocity, C_m is the maximum capacitance during the cycle, and θ is the phase angle between the start of the voltage cycle and the start of the capacitance variation cycle. The practical formula for the average power developed by this synchronous electrostatic machine with sinusoidal capacitance variation in terms of its dimensions can be shown to be

$$P_a = \frac{139 \times 10^{-15} E^2 f s (r_1^2 - r_2^2) \sin 2\theta}{d}\ \text{watts}$$

where E is the maximum value of line voltage of frequency f, s is the number of rotor disks, r^1 and r^2 are the inner and outer radii of the rotor, and d is the rotor and stator separation in centimeters. This synchronous a-c machine may be arranged for single or multiphase operation; except for the stator supports, it is constructed entirely of metal and has its moving rotor permanently connected to ground potential. Figure 10 shows an experimental machine of this type which has operated in high vacuum with an output of 60 watts and with a measured efficiency of slightly higher than 99 per cent. This electrostatic machine operated with a maximum 60-cycle line voltage of 90 kv and a gradient of about 100 kv per centimeter. It is to be recognized that such vacuum-insulated electrostatic machines are entirely free from magnetic losses, have relatively little I^2R loss because of the high voltage and low resistance of the machine circuit, and have exceedingly low dielectric loss and no windage losses because of the nature of vacuum insulation. When such equipment can be operated at higher voltages and gradients between the interleaving metallic electrodes, its power compactness will approach that of conventional electromagnetic apparatus.

D-C Electrostatic Generator for Operation in High Vacuum. A d-c electrostatic generator of the interleaving metallic plate type (Figure 11) may be arranged so that the rotor–stator capacitance varies cyclically between a minimum value C_0, and a maximum value C_m. The rotor is insulated from ground and maintained at a voltage V relative to ground by an auxiliary supply. The stator is connected to the junction of two electronic

tubes which are connected in series across the d-c line at $-E$ volts. To generate negative electric power, the rotor-inducing voltage V must be positive, and the tubes must be connected as shown in Figure 11. The cycle for the generation of negative electric power is as follows: When C becomes equal to C_m, tube 2 ceases to be conducting. At this point the stator is at ground potential. Full line voltage E exists across tube 1, and full inducing voltage V exists across C_m. The electric charge between rotor and stator is, therefore, $Q_m = C_mV$. As the rotor turns, the capacitance C diminishes. As neither tube now is conducting, the voltage across C increases, the stator becoming more and more negative relative to ground. When the stator attains line potential, tube 1 becomes conducting, and further movement of the rotor causes the charge to leave the stator and to flow onto the line. Tube 2 now is withstanding full line voltage E, and the charge left in the generator system at this point is

$$Q_0=C_0(E+V)+(C_S+C_V)E$$

The average output power is

$$P_a=\frac{4.63\times10^{-15}Knsp(r_1^2-r_2^2)VE}{d} \text{ watts}$$

where

$$K=\frac{1-C_0(E+V)+(C_S+C_V)E}{C_mV}$$

n is the rotation per minute, s is the number of rotor plates, d is the separation between rotor and stator in centimeters, r_1 and r_2 are the radii of the rotor in centimeters. In a practical machine design, a value of $K = 0.75$ can be obtained.

Let us consider the power output of an electrostatic generator based on the assumption that voltages of 1 million volts and gradients of 1 million volts per centimeter can be insulated reliably in high vacuum between rotor and stator. If such practical details as the desirability of sectionalizing and phasing the stator are ignored, the generator action is distributed over the entire cycle. The 1 million volts might be divided equally between the inducing voltage V and the line voltage E. Under these conditions a machine with 4-foot maximum and 2-foot minimum rotor diameters, 50 rotor plates, 16 rotor poles, rotating at 4,000 rpm, would develop a maximum power of about 7,000 kw. Such a generator would have dimensions of about 6-foot diameter by 10 feet long.

The use of vacuum-insulated machinery for the generation of considerable amounts of power is necessarily speculative at this time because of the great dependence of power compactness upon the realization of higher insulating strength between electrodes in vacuum. It is not improbable, however, that such improved performance may be realized, as vacuum should be more amenable to exact scientific study than material insulating media and as up to this time its high-voltage insulating properties have been almost neglected as a subject of investigation. Should such use of vacuum insulation in power engineering be attained, it would indeed be a macroscopic production of a situation analogous to that which exists in the structure of atoms, which are in effect systems operating under the influence of electrostatic forces and insulated in high vacuum.

Figure 10. Vacuum-insulated synchronous electrostatic generator

Electrostatics, if ever it is applied to electric power engineering, will have an advantage in its inherent effectiveness for high-voltage operation. This is in line with the modern tendency, in that the need to utilize and transmit larger blocks of power requires increasingly high voltages for reasons of efficiency and stability. The adaptability of electrostatic machines to the generation and utilization of constant-potential power increases the attractiveness of such devices.

THE POSSIBILITY OF DIRECT UTILIZATION OF ATOMIC POWER

When this stage of speculation is reached, it is of interest to go still further and to inquire whether

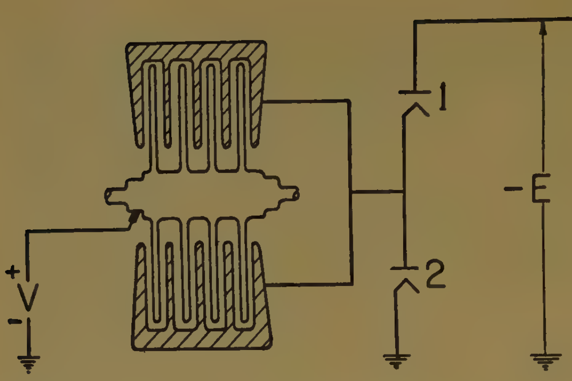


Figure 11. Schematic diagram of one type of variable-capacitor constant-potential electrostatic generator for operation in high vacuum

C_s = *capacitance of stator to ground*
C_v = *capacitance of tube 2 to ground*

electrostatic devices may not have special adaptability to the utilization of atomic energy. A large fraction of the energy released in nuclear reactions is released in the form of kinetic energy of electrically charged particles. The energy of these particles is usually of the order of millions of volts and generally is distributed over a wide energy spectrum. It is conceivable, however, that radioactive isotopes could be produced by nuclear piles which emitted particles fairly homogeneous in energy and at levels of about 1 million volts. Such unstable materials, if placed on a vacuum-insulated terminal, would tend to maintain that terminal at a voltage above ground equal to the maximum energy of the ejected particles. The current delivered by a nuclear generator would equal the number of particles reaching the surrounding ground electrode per second times their electronic charge. By connecting this constant-potential power to a vacuum-insulated motor as described, the high-voltage power could be converted into mechanical power of rotation and then into conventional forms. Although there are several practical difficulties for which no immediate solution is seen, such a procedure offers a means, in principle at least, of utilizing—without the intervention of a heat cycle—the kinetic energy of the charged particles produced in nuclear disintegrations.

CONCLUSION

This has traced very rapidly the development of electrostatic ideas from ancient and medieval times to their present realities and their future implications. The directness and essential simplicity of electrostatic phenomena and their intimate relation to the structure of matter and, therefore, of energy itself have been noted. In practical application to the generation and utilization of electric power, electrostatics has suffered by the limitations of materials, notably the insulating media which are essential to the development of large forces in compact apparatus and which are available in atomic dimensions. It is not unreasonable to believe that these limitations may be reduced considerably in the future and that electrostatic high-voltage sources may be developed beyond their present specialized field into the realm of high-power engineering.

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New Telemetering System

A new 15-pound mechanically commutated telemetering system developed by the General Electric Company and designed for use with rockets speeding at 3,800 miles per hour recently was tested successfully at the United States Army Ordnance Proving Ground, White Sands, N. Mex. The system uses only ten electronic tubes and is packaged in two pressurized cans, each four inches in diameter and 12 and 15 inches long. Power is supplied by a separate 28-volt battery, located in the control compartment, which weighs 12 pounds. Every 1/35 of a second 28 items are sent by the 5-watt transmitter in the rocket and are received at the ground station where they are recorded permanently on film from one cathode ray oscilloscope.

Also tested at the same time was a gyroscope steering control system which operates in response to command signals given by a timing device located within the rocket. This steering control is capable of controlling the flight of the missile right and left, as well as up and down. Information regarding operation of the gyroscope steering control was transmitted to the ground through telemetering channels.

An Approach to the 5-Year Curriculum

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How should the 5-year engineering college program be apportioned among the many subjects contending for the student's time at every level of his training? To date this question has been sidestepped even by proponents of the "5-year plan." With the 5-year program already adopted in some institutions, as recommended by ASEE, the question moves into the forefront of the battle currently waging over engineering curriculums. One of the first to enter the field with a comprehensive philosophy on which decisive action can be based, the author nevertheless leaves several problems in abeyance, pending further study by the psychologists.

ONE DOES NOT BUY a house without looking at the floor plans. The faculty of an engineering college intelligently can not adopt the "5-year plan" without a knowledge of how the additional year of study is to be employed. Though various committees of the American Society for Engineering Education and other organizations have made recommendations concerning how the students' time might be employed most profitably, these suggestions are usually in percentages of the total, and are not of too much help when attempts are made to divide the recommendations into specific course hours. The suggestions likewise usually are couched in general terms as "technical courses," and "social or humanistic." Disagreement arises in any faculty when courses must be placed in one or the other category, or content descriptions of broadened courses written, or when the manner in which such courses are to be introduced into the curriculum is discussed.

This article is written to express one fundamental approach to the problem, not of whether the 5-year program is desirable, but of how and when to introduce new and socially broadening material into engineering curriculums, if a fifth year is to be added. To return to the opening metaphor, this is one possible arrangement for the rooms of our house, in which a social living room is added to a technically satisfactory kitchen, with interconnecting passageways making the house a livable whole.

Generalized solutions to a subjective problem are dangerous, that is, to group all students together and say that any one method of handling is best for all is to say that all students are alike, an obvious fallacy. Any solution to the enlarged engineering curriculum problem must allow for adequate variations to suit the needs of various classes of students. Engineering curriculums long have been known for their rigidity, possibly a necessary feature, but, in endeavoring to broaden our base, we should make sure that the rigidity in our narrowed field is not carried over into an equal rigidity of the broadened field. In a restricted area, students may be assumed to have the same needs, but in an enlarged area they must be treated as having differences. Water flowing in a river is channeled and controlled, but water allowed the freedom of an ocean develops many cross currents. If broadened curriculums are to be offered to our engineering students, we should not make the mistake of requiring the same courses of all students, but should insure a general widened outlook, with opportunity for them to follow further any interests aroused.

Proponents of a lengthened engineering curriculum usually state that engineers are narrow, or have a restricted field of interest. In any detailed planning of engineering training to overcome this fault, it would help greatly if we had the answer to a major question: "Does the engineering curriculum force engineers to a restricted field of interest, or does engineering attract a type of mind which would tend to narrow specialization in any field?" In other words, does the difficulty lie in the process or the raw material? An answer to this question would seem to lie in the field of psychological research and should be obtainable. If such an answer were forthcoming, a much more definite basis would be available for planning the use of increased time in the engineering college. Lacking the results of such research, we can attempt only to plan in a way that will straddle the issue, not necessarily an efficient solution.

THE PROPOSED PLAN

As a general plan of attack, to meet the points just raised and possibly to achieve some subsidiary ad-

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vantages, the first year of the engineering curriculum might be spread out to two years, or the first two years spread out to three years. The added time then might be used for courses in social and humanistic studies. In either case, the upper class years would remain much as at present, except for inclusion of more free electives and changes in required course material to take advantage of improved teaching of the fundamentals in the early years.

A number of advantages might accrue from such a treatment. The added broadening courses in history, sociology, economics, psychology, English, as examples, necessarily would be basic or beginning courses in those fields. The freshman engineer would be taking these courses simultaneously with freshmen majoring in other curriculums, and would enjoy an interchange of ideas with these students on an exactly equivalent basis. At this level segregation of engineers into special sections would be undesirable.

If the starting of work in any of these fields were delayed until the upper class years of engineering, the so-called basic, or freshman, courses still would have to be taken before more serious work in the field. However, it is then a case of an upper classman, whose working speed has been increased much beyond that of a freshman, taking a course designed to move at a rate and at a level suitable to a freshman. That rate is so slow that the upper classman becomes bored, and the level is so low, that the upper classman "can see nothing to that stuff." If, to counteract this attitude, the engineers are placed in separate sections, then the valuable contact with men expected to major in other fields is lost, and we are accentuating further the feeling of the engineering student that he is a creature of special virtues and above the common throng. In effect, we make him narrow by refusing to allow him to mingle.

A second reason for beginning work in the social or humanistic areas early in the student's curriculum lies in the nature of engineering teaching in certain fields. The form of teaching referred to is the development of results by logical "proof," usually mathematical derivation. The student is taught to expect, to rely upon, and to develop by himself, basic laws and relations, usually stated in mathematical formulas. An advanced engineering student, in fact, actually may be suspicious of any result not capable of such derivation and statement. This attitude may be advantageous in the exact sciences, but may lead to confusion, argument, and finally derision of an instructor in economics, psychology, or sociology, who, by the very nature of his subject matter, is unable to state his laws so exactly. If the student is exposed to teaching in the social subjects before the engineering method of mathematical proof is ground into him so thoroughly, he may accept with willingness the processes of logical reasoning applied, and actually benefit later on by use of them in his own engineering work.

ADVANCED SOCIAL AND HUMANISTIC STUDIES

Time for more advanced work in the social fields may be found in the second or the third year. Here some advantages might be obtained by segregation of the engineers into separate sections to study in greater detail certain of the more advanced phases of economics, history, sociology, and so forth. At this level, the engineer already has begun to move into his field of specialization—the narrowing process of the engineering curriculum may have begun, if the trouble lies therein—and in some cases motivation for taking additional general or broadening courses may have to be supplied.

Good teachers who could supply this motivation might find their load considerably reduced, if their courses could be taught by indirection. Could not an excellent course in American history be built around the title "History of American Engineering?" The transport and communication problems involved in the American Revolution, the effect of the national road and the building of the Erie Canal on the westward movement, the steamboat, the first transcontinental railroad, electricity, are only a few points in engineering history which could be discussed in their effects on American life and American history.

Likewise a course in "Sociologic Effects of Great Inventions" could take up the wheel as a first point, include the printing press, the telegraph, the steam engine, the cotton gin, and the gasoline engine, as only a few of the many inventions which have left their mark on civilization. Psychology, from the labor and management standpoint, and the economics of various engineering businesses and industrial concerns also should provide valuable material. In each such course, reasoning would be from the specific case back to general principles, and, given instructors capable of arousing interest and leading discussions, the students often should be able to carry on alone.

GOOD TEACHERS REQUIRED

Good teachers, as mentioned, of necessity would be a requirement for the success of such a program. The danger in the broadened program lies in the ultimate treatment by the social study departments concerned, of all such courses as service courses. Their best instructors naturally are required for work with students majoring in their fields. The plan as proposed, by avoiding segregation in the elementary courses, insures teaching at that stage at least as good as that given to students expecting to major in the field. The success of the more advanced courses depends entirely on engineering colleges' being able to impress the importance of these courses on the departments concerned and pointing out to them the challenge inherent in coupling engineering with their fields. It should not be too difficult to find a few men interested enough in teaching really to work on such an assignment. Some

interchange of staff might aid. For instance, an English professor might improve his teaching of composition to engineers if he better understood the nature of, and reasons for, the engineering report.

As previously pointed out, after grounding in several fields in the social and humanistic area, all students should not be expected to take rigidly required advanced courses. Again this would be implying that all students are alike, a particularly dangerous generalization in a broadened field. Ample opportunity for free electives should be provided in the upper class years, so that each student can go further into any field which has particularly caught his interest through the basic courses. However, all students should be required to take some advanced social courses. Our liberal arts brethren long have preached the advantages of the elective system. These courses are in their field, and their experience should be weighed. Only through sowing the seeds of interest in the first courses, with very careful later cultivation of the seeds which sprout, can the goal of a well-rounded engineer, with interests beyond the strictly technical, be achieved.

TECHNICAL COURSE CONTENT

So far the technical content of the curriculum has been disregarded. Essentially it probably need not be changed. By this time the engineering teaching profession has a fairly definite idea of what material should be included. The basic work in mathematics, chemistry, physics, still could be covered in the first three years, possibly at a pace slightly reduced from our present standard. In the case of advanced engineering work, care should be exercised by those in responsible charge that the increased time in the curriculum as a whole is not used as a means of introducing further specialized technical courses. If we confine ourselves to the teaching of fundamentals, leaving specialized training to graduate work or to the industries for their individual needs, it should be possible to achieve a satisfactory result within the time available.

By improved teaching and concentration on a few fundamentals of technical work in the early years, we may be surprised to find that much less repetitive teaching is needed, and much more may be achieved in courses in the senior year. The present electrical engineering curriculum at Iowa State College employs this philosophy, and results so far obtained bear out the correctness of the foregoing statement.

No attempt has been made here to argue the desirability of five years in the engineering curriculum. That is another and entirely separate question with its own pros and cons. However, it is believed that the statement that five years are necessary can not be accepted rationally any more than a statement that all cans of tomatoes containing over ten ounces are good. In the latter case we are not convinced that there is a relationship between size and quality, without investigation of the contents. Neither can we accept a 5-year program as desirable without consideration of the contents of that program.

In this whole matter, generalization is dangerous. As has been pointed out, to replace four years of rigidly specified engineering courses over a narrow field with five years of just as rigidly specified courses over a broad field is exceedingly dangerous. If students' characteristics were plotted as sets of curves, these curves all could be matched and made to fall upon one another over a sufficiently narrow region. To assume from this that the curves are alike over the whole region is obviously a fallacy.

The 5-year program is an experiment, with desirable objectives. To experiment we must have a plan. One possible plan is presented here.

Underground Industrialization

Completely underground facilities constitute one of the most effective means for protecting aircraft production against air attacks of the type employed during World War II. This conclusion has been reached by the Air Matériel Command which, acting for the United States Army Air Forces, currently is studying German underground industrialization.

The first German underground factory on record was a precision instrument plant installed in caves at Mulhausen, Thuringia, as early as 1917. In 1943 the German *V-2* bomb project was moved underground, and in 1944 Hitler ordered an organized effort to move aircraft factories to underground sites. However, disrupted conditions and lack of time prevented full realization of the underground program in Germany.

The Germans attempted two general types of underground construction: one, a semiunderground structure, intended to withstand the heaviest known bombing attacks; and the other, a complete underground plant. One type of semiunderground structure was the submarine pen, a massive vault with huge wall and ceiling coverages of heavily reinforced concrete. A second type, the "bunker" plant, consisted of large dome-shaped semiunderground structures with reinforced concrete convex roofs, 9 to 18 feet thick. These structures averaged about 80 feet and four to six stories in height, and allowed approximately 1,200,000 square feet of floor space, 40 per cent of which was underground. Although none of the bunker-type projects were completed in time to be put into operation, this type of construction probably represents the most suitable type of semiunderground installation designed by the Germans because it combined large areas of free floor space, adequate height, and ease of access, with a certain degree of effective protection.

Metering With Transformer-Loss Compensators

G. B. SCHLEICHER
MEMBER AIEE

The transformer-loss compensator is proposed as an economical answer to the problem of metering on the low-voltage side of the transformer, where supplying and billing for energy and demand must be done at distribution or transmission voltages. Use of the compensator, an accessory to the regular watt-hour meter, necessitates no changes in the meter, and its accuracy has equaled that of meters on the high-voltage side.

THE FUNDAMENTAL PRINCIPLES by which compensation for transformer losses is possible have been known to engineers for many years. Copper losses vary as the square of the current, and for practical purposes iron losses vary as the square of the voltage. Various networks have been designed by engineers to meet the metering requirements of specific installations, and the compensating meter was developed to make possible routine metering installations on the low-voltage side for utility customers supplied from high-voltage lines. The methods in use are

1. Compensating metering[1] in which a separate meter, connected to the low-voltage side, registers the transformer losses. Its registration is added to that of the regular watt-hour meter to obtain billing quantities in terms of the high-voltage side. The disadvantages of this method are that a special meter is necessary, the measurement of maximum demand is more complicated than with high-voltage metering, and special test equipment, normally not carried by meter testers, is required.

2. Line-drop compensators can be used to compensate the load watt-hour meter for copper losses,[2] but the commercial forms have the disadvantage of introducing relatively high burdens into the current transformer secondary circuits. Burdens have been reduced to some extent by omitting the reactance unit, which is not necessary where the desired measurement includes only power measurements.[4,6] However, application of these devices generally requires special test equipment, and their periodic testing by conventional methods is outside the scope of metermen.

3. The adjustments of the meters themselves can be used to approximate the losses.[3] Light-load adjustment of meters can be made to compensate quite closely for core losses, but, as the full-load adjustment in principle raises or lowers the entire characteristic curve of the meter, its use for copper-loss compensation involves compromises in performance. In general, this method is suitable for billing only where the meters are known to operate within certain load ranges, or where the copper losses are relatively small.

4. The addition of calculated losses to load registration has been advocated, and, though feasible from an engineering point of view, this is practical only in special cases for utility billing of customers' loads. Loss factors may vary widely, not only between customers but also for the same customer from month to month.

5. The transformer-loss compensator described in this article has been designed to compensate for the transformer losses for the range of conditions that are characteristic of metering on the low-voltage side, where service is supplied at distribution or transmission voltages. No changes are made in the regular watt-hour meter, either in construction or in its method of adjustment; the burdens imposed on instrument transformers are sufficiently low to be acceptable for metering installations; and the measurement of demand in terms of the high-voltage side introduces no complications where a single transformer bank is installed. The methods of procedure that have been developed permit both the initial calibration and the routine maintenance of the installations to be done by metermen, who are capable of handling the corresponding installations on the high-voltage side. These methods may be adapted to any system of meter testing practice.

PRINCIPLE OF TRANSFORMER-LOSS COMPENSATOR

In the transformer-loss compensator, the line-drop compensator principle is used for adding the copper-loss increment to the registration of the load watt-hour meter. The burden imposed on the instrument transformers has been made sufficiently small to be acceptable for metering installations by designing the insulating transformer to step down rather than with the one-to-one ratio used in the commercial forms. The ratio of 5.0 to 0.5 amperes has been found to be satisfactory, but its exact value is unimportant when the methods of adjustment described in this article are used. Commercially the copper-loss transformer is a 5-volt-ampere, 1-volt 5-ampere to 10-volt 0.5-ampere unit, of good phase angle performance and is designed to be capable of carrying 100 per cent overload continuously. The 0.5-ampere side is connected to an adjustable resistor unit for which a value of 5 ohms has been found to meet the general range of requirements of commercial installations. Higher or lower resistor values may be used for unusual conditions. The difference of potential across the resistor is added to the secondary line voltage,

Essential substance of paper 47-116, "Metering With Transformer-Loss Compensators," scheduled for presentation at the AIEE summer general meeting, Montreal, Quebec, Canada, June 9–13, 1947, and for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

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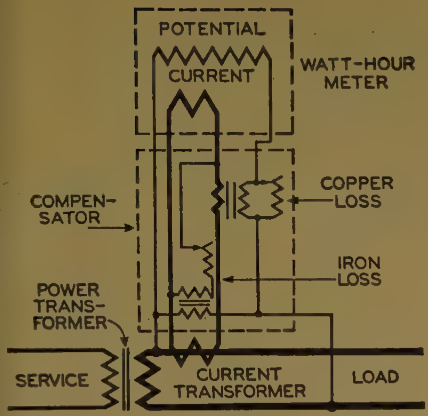

Figure 1. Principle of transformer-loss compensator

and the combination is applied to the potential coil of the meter. As the voltage across the resistor is proportional to the current, the loss increment as registered by the watt-hour meter is proportional to the square of the current.

For the measurement of the iron-loss increment, the "dummy load" method is used.[4] A 7.5-volt-ampere 230/6-volt transformer is connected to the low-voltage supply, and the 6-volt side is connected in series with an adjustable resistor unit, so that a current equivalent to the iron loss is passed through the current coil of the meter. Ordinarily a 250-ohm adjustable resistor gives sufficient range, but units of higher or lower values of resistance may be used, if necessary, to obtain the desired performance. For 115-volt circuits the transformer has sufficient capacity to be operated at half voltage. Therefore, the compensator may be used either for 230-volt or 115-volt installations, or on the secondary of potential transformers. Figure 1 shows the principle of operation.

The assembly of transformers and resistors, together with a double-throw test switch and a terminal block, is intended as an accessory to the watt-hour meter, and its connections to a single-phase circuit on the low-voltage side of a transformer are shown in Figure 2. In its normal position (up) the test switch of the compensator connects the transformer-loss compensator into the circuit, and the transformer losses are included in the registration of the watt-hour meter. When the switch is in the test position (down), the transformer-loss compensator is inoperative; the meter is connected as a watt-hour meter and may be subjected to all of the tests common to ordinary testing practice, including the test for creep. The cover of the test switch cannot be replaced while the switch is in the test position, and the connections used require no changes in grounding practice of current transformer and potential transformer secondaries.

POLYPHASE TRANSFORMER-LOSS COMPENSATORS

In the practical application of transformer-loss compensators, there is little need for the single-phase device. Usually single-phase loads are supplied from low-voltage distribution circuits or networks, and are metered and billed at the supply voltage. For polyphase circuits, duplicates of the single-phase unit may be used, but polyphase transformer-loss compensators are more practical. Two arrangements meet all requirements, one for use with 2-element meters, the other for 3-element meters.

For polyphase circuits, it is practical to add the entire iron loss on one meter element, hence only one core-loss transformer is used in polyphase transformer-loss compensators. The 2- and 3-element internal connections are shown in Figures 3 and 4, respectively. The connections of the compensator into a 2-element circuit is shown in Figure 5, and for a 3-element circuit in Figure 6. A typical 2-element installation can be seen in Figure 7.

In the interest of simplicity, potential transformers are not illustrated. It is obvious, however, that, where potential transformers are used with metering on the low-voltage side, the voltage applied to the meter may be applied also to the potential element of the transformer-loss compensator. Compensator connections of Figure 5, shown with a power transformer bank connected in open delta, are applicable to any other transformer connection from which a 3-phase 3-wire supply

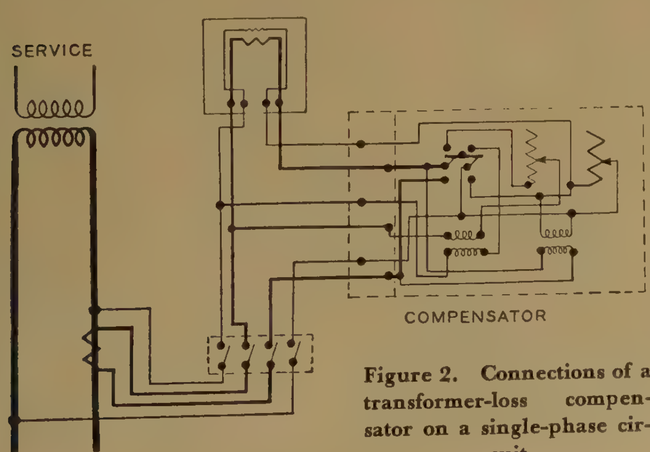

Figure 2. Connections of a transformer-loss compensator on a single-phase circuit

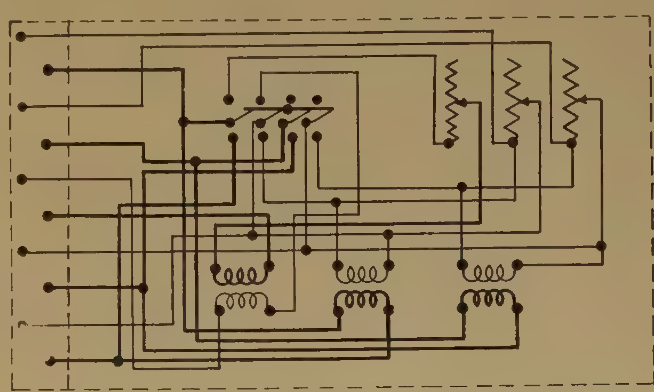

Figure 3. Internal connections of 2-element transformer-loss compensator

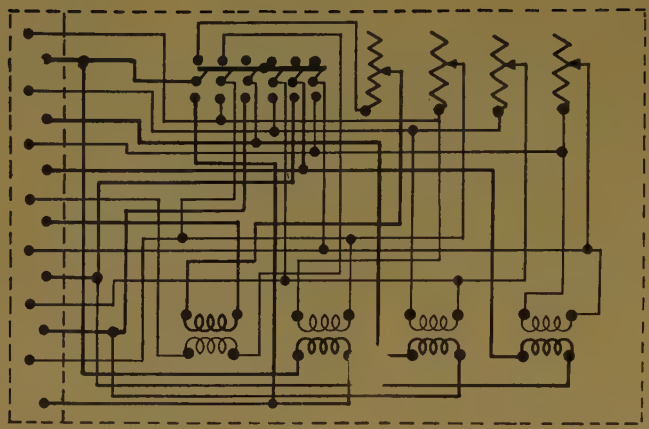

Figure 4. Internal connections of 3-element transformer-loss compensator

may be obtained in the low-voltage side. In all cases the type of circuit on the low-voltage side determines the proper metering.

INSTALLATION

A transformer-loss compensator may be added to an existing installation which measures the entire output of a transformer bank on the low-voltage side. On installations of this type, however, there should be no means of disconnection between the low-voltage terminals of the transformer bank and the point where the meter potential transformers, or the meter potential circuits, are connected. This is necessary so that iron-loss registration may be obtained whenever the transformer bank is energized from the high-voltage side, even though the load may be disconnected.

ECONOMIC AND OTHER CONSIDERATIONS

The economy of using transformer-loss compensators is greatest for the higher supply voltages. The cost of of a 460-volt or 230-volt metering installation compensated to the 33-kv supply may be less than 30 per cent of the metering cost at 33 kv, thus saving approximately 70 per cent. For a 13.2-kv supply, savings may be only 20 per cent, whereas for a 2.3-kv installation metered at 230 volts, metering at the supply voltage is frequently lower in cost. In the latter case, an exception may occur where existing 230-volt metering can be used with no change other than the addition of the transformer-loss compensator.

Where more than one metering equipment on the low-voltage side is required in place of a single installation on the high-voltage side, the economic advantage of low-voltage metering is reduced, and sometimes eliminated entirely.

The application of transformer-loss compensators to metering on the low-voltage side, as compared with

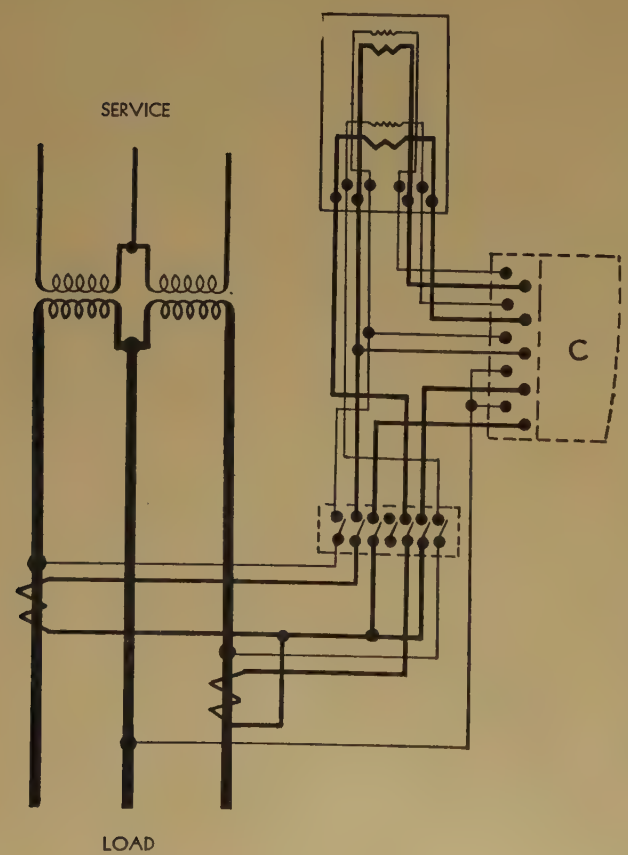

Figure 5. Connections of 2-element transformer-loss compensator on 2-phase 3-wire or on 3-phase 3-wire circuits

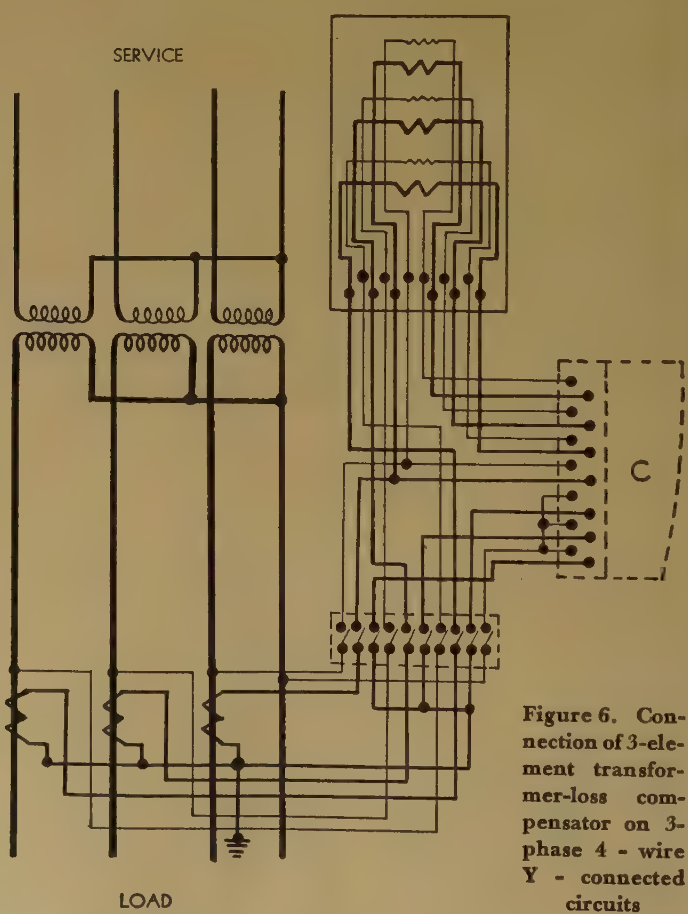

Figure 6. Connection of 3-element transformer-loss compensator on 3-phase 4-wire Y-connected circuits

metering on the high-voltage side, is found to be advantageous:

1. When the metering cost is appreciably lower than metering on the high-voltage side.

2. For exposed locations on the system, where high-voltage instrument transformer equipment may be expected to be troublesome because of lightning or other disturbances.

3. When the limited available space makes the installation of high-voltage metering equipment difficult, hence more expensive.

4. When a customer with a rate for low-voltage service is changed to a high-voltage service rate.

Generally speaking, metering on the high-voltage side should be preferred:

1. Where multiple compensator installations are necessary in place of one metering equipment on the high-voltage side.

2. Where a part of the load is used or distributed at the supply voltage (high-voltage metering is necessary in this case).

3. Where the cost of high-voltage metering is lower than a compensator installation.

ACCURACY PERFORMANCE

Comparing laboratory test results of a watt-hour meter and transformer-loss compensator combination with tests of the watt-hour meter without compensator shows that the characteristics of the meter with compensator reflect, within the accuracy of the tests, the performance of the meter alone.

Tests in service on five actual installations showed that performance of the meters with loss compensators compared with the high-voltage billing meters to range from 99.84 per cent to 100.26 per cent, with an average of 100.08 per cent. This performance is well within the requirements of public utility commissions. The tests lasted 13 weeks, during which the total registration amounted to over 2 million kilowatt-hours.

Conditions may arise where the iron loss alone is less than the starting load of the meter, or even the load under which the meter will continue rotating when the load is reduced. The same limitation applies to a watt-hour meter on the high-voltage side. The integration of iron loss alone is somewhat more accurate for meters with transformer-loss compensators than with actual measurement on the high-voltage side, because iron loss is added at power factor 1.0, where the performance of meters is better than at the lower power factor of the iron loss itself.

METER TESTING

Any method of meter testing may be used with transformer-loss compensators, but, as the total loss curves are not straight lines, the tests with and without compensator should be made at approximately the same test load, and as closely as practicable to the nominal values of test load. Where fixed phantom load devices are used, it is desirable to provide a separate tap in the heavy-load circuit, so that approximately the same current will be passed through the meter when the compensator is in circuit as when it is short-circuited for tests on the meter alone.

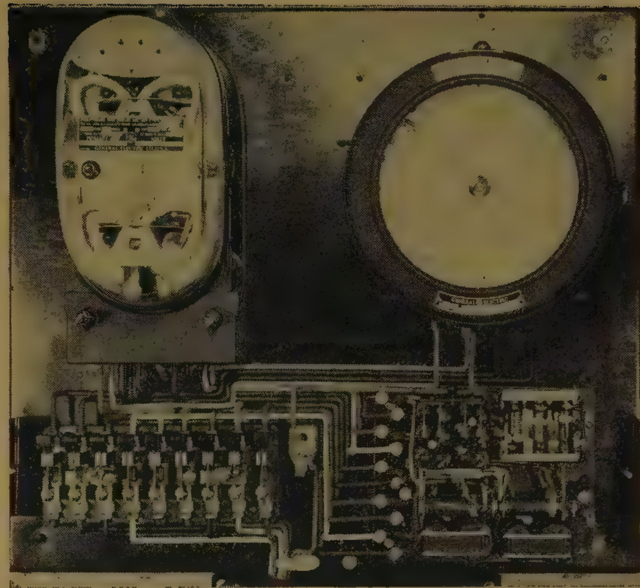

Figure 7. Typical 2-element meter panel with graphic demand meter and transformer-loss compensator (panel cover removed)

POWER FACTOR TESTS

In some utilities, power factor tests are made on customers' loads from time to time. When transformer-loss compensators are used for the watt-hour meter, such tests may be made on the low-voltage side and corrected to the point of supply by calculation. The procedure is the same as for compensating metering. This is described in Appendix *A* of reference 1.

VAR-HOUR MEASUREMENTS WITH TRANSFORMER-LOSS COMPENSATORS

In some utilities, var-hour meters are used for determining monthly average power factor, or, with a demand meter controlled by the var-hour meter, power factor at the time of maximum demand. The most common type of var-hour meters used on polyphase circuits are watt-hour meters connected to autotransformers that provide a 90-degree phase displacement for the meter potential circuits. No actual installations of this type have been made with transformer-loss compensators, but the results of tests indicate that the principle of the transformer-loss compensator may be applied also to var-hour meters of this type.

OTHER APPLICATIONS

Though this paper deals largely with the routine application of compensators for utility metering installations on customers' loads, other applications will be evident. For example, in statistical metering, losses of step-up and step-down transformer banks together with line losses may be included in a transformer-loss

compensator to provide metering as of a remote point. Compensators may be connected to subtract losses if desired, hence they may be applied to metering in tie lines.

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Characteristics of Hydraulic Turbines That Effect Operating Efficiency

J. F. ROBERTS

A review of the problems confronting the engineer who must improve the operating efficiency of his hydro plants is presented because worth-while saving to the operating company often can be suggested by the hydraulic turbine manufacturer.

DISCUSSION of the problem of efficient operation of hydroelectric equipment is not new, but its importance to electrical and operating engineers is so great that a review may be worth while.

CURVES OF EFFICIENCY

Figure 1 shows the shape of the efficiency curve of various types of runners used in hydraulic turbine equipment. This covers different types from the high head impulse wheels suitable for heads from 1,000 to 2,000 feet down to the fixed blade propeller wheel which might be used for heads as low as ten feet. All these curves show turbine efficiency only and do not include generator losses.

The Kaplan turbine has the best part load efficiency, the impulse turbine running it a close second. But for the highest peak efficiency the runner with the specific speed of about 53 and showing a maximum efficiency of 94.5 per cent at 80 per cent load is by far the best performer in the hydraulic turbine field.

POWER SYSTEMS

In operating a power system, the possibilities and variations in operating procedure multiplied by the number of plants and different types of plants are further complicated by a combination of hydro and steam plants.

The simplest system to operate is an isolated power system with only one generating unit. On such a system this one unit must be operated to supply the load requirements as they occur. As long as the unit is kept properly maintained and in good operating condition, very little remains that can be accomplished, even though the operating superintendent has a perfect understanding of the efficiency characteristics of the unit.

Next in simplicity is a system consisting of only one power plant but having several duplicate units installed in that plant. A simple rule to be followed here is to carry the required load with the minimum number of units possible in operation at any time. By studying the curves shown in Figure 1, it will be noted that at half load the efficiency of practically all types of hydraulic turbines is less than the full load. Even with the Kaplan or impulse wheel only one unit should be operated until that unit is loaded up to about 98 per cent of its capacity. The second fundamental rule for this type of a system is to divide the load equally on similar units. The shape of the efficiency curve on all hydraulic turbines is fairly similar in that the efficiency curve rises swiftly at part loads and gradually flattens out until the point of maximum efficiency occurs but is convex upward.

The third type of system in order of complication is a system containing two or more plants each with a multiplicity of units. Alternatives regarding complications in system arrangement could be increased to infinity, but

Essential substance of a conference paper presented at the session on hydroelectric systems at the AIEE winter meeting, New York, N. Y., January 29, 1947.

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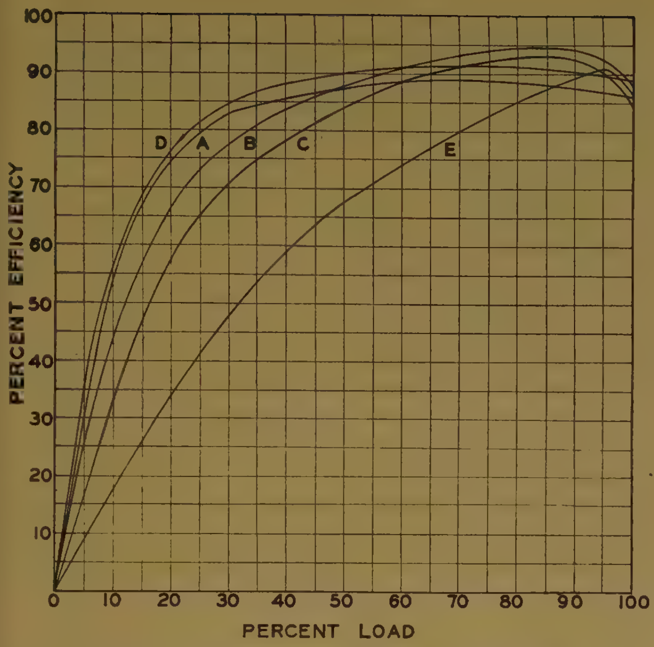

Figure 1. Typical shapes of efficiency curves

A—An impulse wheel from a unit rated 30,000 horsepower under 1,200 feet of head and having a specific speed of about 4.8
B—A Francis-or reaction-type turbine suitable for about 200 feet of head, 100,000 horsepower, and a specific speed of 53
C—A reaction turbine rated 35,000 horsepower under a 90-foot head and having a specific speed of about 78
D—A Kaplan turbine developing about 40,000 horsepower under a 70-foot head and having a specific speed of about 120
E—A fixed blade propeller-type turbine rated 45,000 horsepower at about 45-foot head and specific speed of 140

in general there is no doubt that the problems of the efficiency expert on the operating staff of a large power system increases with the number and type of plants interconnected.

Storage Systems. A system having some units operating on storage water and other plants working on run-of-river flow increases the problem in that the run-of-river plants must be loaded to utilize the entire flow of the river. The load must be adjusted between units to give the maximum kilowatt output for that flow so as to require a minimum of water to be drawn from storage. Where the run-of-river plants contain Kaplan-type units, the load variations on these units can be considerable without a serious loss in efficiency. Where the daily load factor varies appreciably and the night load is materially less than the day load and the system contains both run-of-river and storage plants, the problem must be studied and calculations made to determine the proper distribution of the load between plants for each hour over the day and night period. In some cases even though the run-of-river plant contains only a slight amount of storage, that storage must be drawn down sufficiently during the heavy load period of the day in order to avoid spilling during the light load of the night period where the total load on the system might be less than the average output of the run-of-river plants operating alone during that night period. The river flow is bound to vary from season to season and even from day to day, necessitating continual vigilance. A set of rules based on two days' stream flow may have to be entirely revamped two days later.

Steam and Hydro Plants. At the present time large hydroelectric systems with only water power are few considering interconnected systems. Probably only some Canadian power systems can be put into this classification.

The Tennessee Valley Authority, one of the fastest growing publicly owned utilities, has an appreciable amount of steam capacity and a total installation of about 2,500,000 kw divided approximately as shown in Table I. Still greater care is required for the efficient operation of such a system.

SPINNING RESERVES

On many systems it is necessary to carry spare capacity over and above the actual generator output requirements as spinning reserve for emergency or as connected reserve able to take up expected increases as the daily peak is approached. A hydraulic turbine operated at speed no-load has very low efficiency. Figure 2 shows the amount of water required for a fixed blade propeller in order to drive this unit at speed no-load producing only enough power to energize the generator. This particular unit operating under a 50-foot head requires about 3,500 cubic feet per second to bring the unit up to speed. This same amount of water would develop 13,000 kw if utilized at 88 per cent combined turbine and generator efficiency. When operated with the wicket gates entirely closed and the runner revolving in air, a generator input of 1,000 kw would be sufficient to drive this unit resulting in a net saving of 12,000 kw which can be stored as water and used later in the day. While this difference is the greatest for propeller-type turbines, it illustrates the advantages to be obtained by motoring units on the line as spinning reserve instead of driving them as waterwheels.

A Francis-type runner rated 80,000 horsepower at 200 feet uses 300 cubic feet of water per minute when driven as a turbine, or the equivalent of 6,000 kw at 88 per cent over-all efficiency. This same unit may be motored in air with only 1,800 kw input, a net saving of 4,200 kw.

AIR VENTING

Figure 3 shows the difference in part load efficiency of a reaction-type turbine of about 78 specific speed when operating at loads from 0 to 50 per cent when air is admitted to ventilate the runner. The admission of air at part loads on such a unit increases the efficiency between 5 and 10 per cent at various outputs and this same relative increase in efficiency can be obtained on practically all reaction-type units varying somewhat with the type of

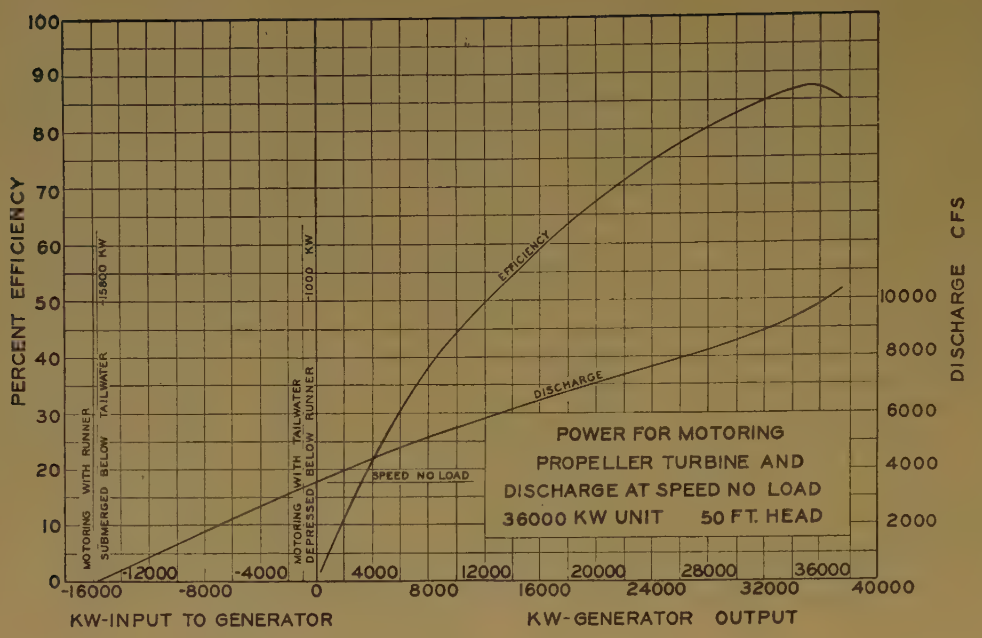

Figure 2. Power and water requirements of a propeller turbine operating at speed no-load when driven as a turbine and when motored with the runner vented

runner and the specific speed. This is true only when the bottom of the runner is above tailwater so that the air admitted will allow the water passing through the turbine to fall free and not be churned up by the runner. Low speed hydraulic turbines of the reaction type for heads between 75 and 400 feet usually can be set with the bottom of the runner slightly above normal tailwater level. During flood times these units may be partially submerged, but when surplus water is available efficiency is not important.

TAILWATER DEPRESSING SYSTEMS

Reaction-type turbines for heads from 400 feet up to the maximum now developed (about 1,000 feet) should be set with the runner below the normal tailwater in order to eliminate cavitation on the runner. Such units if required as spinning reserve should be equipped with a compressed air system for forcing the tailwater level below the bottom of the runner in order to reduce the losses. Such a system will pay dividends not only by the saving in kilowatts but by the increased life of the turbine parts, as high head units deteriorate rapidly when operated at very light loads. Usually pitting and cavitation occurs on the inlet edges of the runners and also on the wicket gates themselves which may result in heavy annual maintenance expense. Kaplan turbines and propeller turbines for heads above 25 or 30 feet are also usually set below tailwater and where this type of unit is used for power factor correction or for spinning reserve, they must be equipped with a tailwater depressing system. For this purpose a large quantity of air must be applied quickly, usually nearly double the volume of the water to be displaced in order to successfully free the runner.

The unit whose performance curves are shown in Figure 2 requires 15,800 kw input to drive the propeller submerged in water but only 1,000 kw when the tailwater is depressed and the runner is revolving in air. The difference is less on Francis- or reaction-type runners, but it is still appreciable.

All modern units are equipped with atmospheric air vents which open automatically at light loads to break the vacuum and allow the tailwater to fall free of the runner, where the runner is located above tailwater. These valves always should be open when the unit is being motored.

GOVERNING

Accurate governing and frequency control often causes loss of efficiency on hydroelectric generating units. On systems where the load fluctuations are serious, as in the case of units in some of the Northern Canada plants with a large load of mining hoists and large air compressors cutting in and out, there may result a continuous governor action with fluctuations of 25 to 50 per cent of the unit capacity. It is difficult to consider loading such a unit at its most efficient point when governing requires such large fluctuation. Certain load variations for governing purposes are an absolute necessity and those units having the flattest characteristics should be the ones to do the governing. However, large cumbersome Kaplan turbines with the added complication of runner adjustment and wicket gate adjustment should not be used for regulation because the continual wear and tear due to movement of the runner blades may result in excessive maintenance. In a combination of low head and high head turbines, the higher head reaction turbines and the impulse wheels should do the majority of the regulating.

EXCITER UNITS AND SERVICE UNITS

Some large plants are provided with auxiliary water-wheel-driven service units or exciter units. Service units

usually operate at such a small percentage of their rated capacity that their efficiency may be below 50 per cent over long periods of the day. Small units deteriorate faster than larger units, because of corrosion, wear, and greater difficulty in getting at the smaller parts for maintenance and proper lubrication. Frequently service units become partially clogged with drift wood or foreign matter, but because these units usually have excess capacity, they are still ample to pull the station load and this loss may go unnoticed for weeks or months.

Direct-connected or motor-driven exciters usually are much more efficient than water-wheel-driven exciters. Station service power taken from transformers is also more efficient. As to reliability, possibly only during times of lightning storms or electrical disturbances is there need for using the less efficient water-wheel-driven auxiliaries.

Some powerhouse designers still insist on installing small service units. I feel that this is an economic waste. Many large and important plants are operating successfully without auxiliary units. Where there is more than one unit in the plant, there never should be a time when station service power cannot be obtained equally well from one of the larger units as from a small auxiliary or station service unit. If an auxiliary unit is a "must", make it a gasoline-driven auxiliary, then the bother of starting will be so great that the operating loss will be a minimum due to so few hours operating time.

LEAKAGE THROUGH WICKET GATES

When a hydro unit is shut down for any appreciable length of time, the head gates or penstock valves should be closed. The water leakage through the wicket gates of a new and modern turbine may run from one per cent to two per cent of full load discharge, and on older and less carefully maintained turbines may exceed five per cent. Closing the head gates or penstock valves should eliminate this loss almost completely.

Some turbines are specially designed to reduce this leakage by means of smaller clearances and rubber seals around the wicket gates.

On impulse wheels for heads up to 2,500 feet failure to close the penstock valve may result, very quickly, in a scored or eroded needle. Serious erosion often occurs on reaction turbines for heads from 300 to 1,000 feet where the pressure is left on the wicket gates for appreciable lengths of time. Such erosion seriously reduces the efficiency of the unit.

TESTS

Performance Curves. No hydro unit can be operated economically without a thorough knowledge of its performance characteristics. Complete performance curves should be made up for each hydro plant showing over-all performance from water to switchboard including all losses such as turbine, generator, exciter, penstock, valve, and intake. Such curves may be based on data obtained from

1. Actual powerhouse tests.
2. Tests of models.
3. Index tests.

Powerhouse tests are to be preferred and full details can be found in the test codes of the AIEE and the American Society of Mechanical Engineers. Where the quantity of water to be measured is large, and the water passages

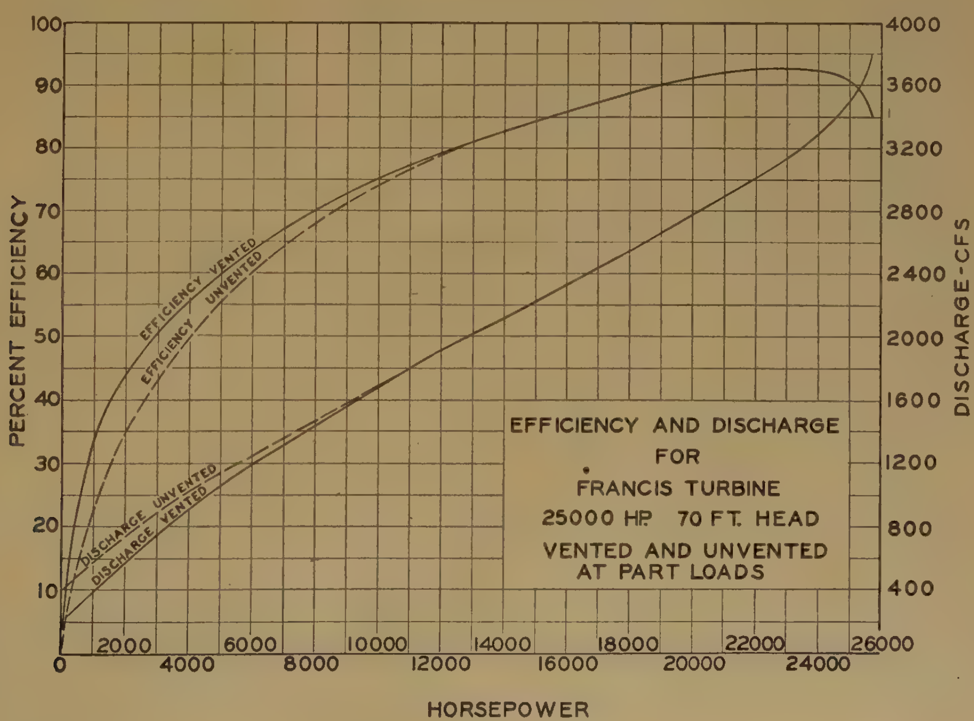

Figure 3. Air venting at part load increases power and efficiency on a 25,000-horsepower unit operating at a 70-foot head

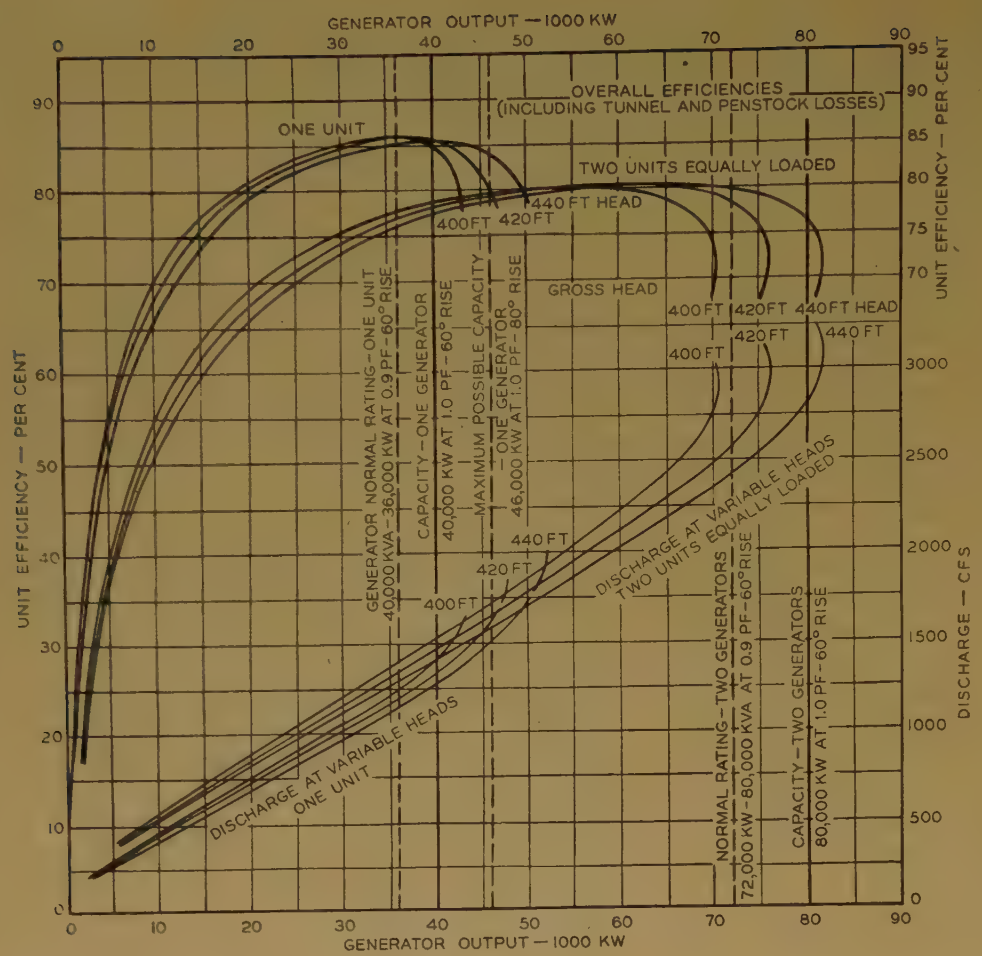

Figure 4. Over-all performance curves for a 420-foot gross head plant containing two 40,000-kva generating units

are relatively short, accurate water measurements are difficult and in this country the methods for such measurements, usually by current meters, have not been generally accepted nor have the results been found entirely satisfactory.

Model tests can be conducted on the turbine and draft tube, but penstock and intake losses must be calculated. Generator and exciter losses can be calculated very closely by the manufacturer. Most hydraulic turbine manufacturers have complete model test data on their turbines and can supply expected performance curves for any installation on which they have complete engineering data.

Index tests do not give absolute values of efficiency, but relative values can be obtained quite accurately. If the over-all efficiency at the best gate is assumed, then the shape of the efficiency curve can be determined for other loads. This type of test is the least expensive to make, and has the advantage over model tests in that the actual capacity of the plant in kilowatts is known.

The plant and its performance curves shown in Figure 4 are interesting because of the fact that tunnel friction through some eight miles of 18-foot diameter tunnel reduces the over-all efficiency when two units are operated, from a peak efficiency for one unit of 86 per cent to a peak of about 80 per cent for two units. Another interesting characteristic is the fact that for full load on two units the tunnel friction increases so fast that with increased flow the power output actually decreases. These curves were prepared from model test data on the turbines and computed losses for generators, exciters, valves, penstocks, tunnels, and intakes. Some revisions may be necessary when index tests are made.

Table I. Division of Capacity of TVA

Type	Capacity in Kw	Number of Plants	Number of Units
Steam	460,000	6	29
Run-of-river hydro	1,400,000	14	66
Storage hydro	660,000	10	16
Total	2,520,000	30	111

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New Cars for New York Subways

B. F. CORDTS

Fluorescent lighting, improved riding qualities, smoother acceleration and deceleration, and noise reduction are some of the numerous improvements incorporated in the new subway cars for New York City. The subway commuter will derive greater comfort and cleanliness from thermostatic heat control, an increased quantity of horizontal fans per car, plastic seat coverings, and wider aisles.

TO meet the increasing need for additional car equipment, the Board of Transportation has placed orders for 400 subway cars to be operated on the BMT and IND divisions, and for 100 subway cars to be operated on the IRT Division of the New York City Transit System.

These cars when put into operation should provide the traveling public with the following:

1. Better lighting.
2. Better riding qualities.
3. Smoother acceleration and deceleration.
4. Reduction in noise.
5. Other items for passenger comfort.

The arrangement of the floor plan of the new cars remains essentially the same; that is, the 60-foot car for the BMT and IND divisions will have a floor plan similar to the present IND cars.

The dimensions and arrangement of the new IRT car also follow the latest type built in 1939. These cannot be changed in width, height, or length because of limitations of the present subway structure.

Wherever possible the body structure and equipment of both types of cars have been made standard to take advantage of the full benefits of such standardization. An artist's sketch of the exterior of this car is shown in Figure 1.

LIGHTING

Tubes of fluorescent light placed end to end for the length of the car provide a distribution of light impossible to obtain by any other means. The problem then became one of selecting the type best suited to the specific requirements of subway service, either hot cathode or cold cathode, each having several desirable and undesirable characteristics.

The cold cathode lamp was selected for the following reasons, especially for reasons 2 and 3.

1. Long life.
2. Life independent of frequency of starting.
3. Instant starting.

The new car will have 24 72-inch cold cathode lamps operating on 600 volts, direct current. Compared to the old IND car an increase of 148 per cent in lumen output is obtained for an increase of 65 per cent in power consumption.

Resistances were used in the circuit in place of two small ballast lamps, because it was felt that the variation in light output resulting from voltage variation was not sufficient to warrant the added maintenance that would be entailed by the use of the small ballast lamps and sockets.

RIDING QUALITIES

Many tests were conducted on subway cars and the records analyzed to see what the effects of various changes made in the truck had upon the riding qualities of the present cars. From these tests certain factors were found to be desirable and were incorporated in the new design. In Table I are shown the proposed changes.

ACCELERATION AND DECELERATION

Rates of 2.5 miles per hour per second acceleration and 3 miles per hour per second deceleration were selected.

The extreme rate of acceleration used for the Presidents' Conference Committee car was not deemed necessary for subway operation because of the

1. *Increased Power Required.* Power peaks would be increased materially if higher acceleration rates were used, and this high demand on power generating stations during morning and evening rush hours would affect their operation, as well as raise the total rate in the case of purchased power.

2. *Complete Change of Type of Control.* Rheostatic control with a large number of steps would be necessary

Table I. Comparison of Old and New Models of IND Cars

	New Cars	Old Cars
Truck frame	Cast steel	Built-up
Bar	Equalizer	Arch
Springs	Coil	Elliptic
Center plate	Conical	Flat
Shock absorbers	Vertical and lateral	None
Bearings	Roller	Plain
Insulation	Rubber*	Rubber

* Increased over old cars.

Essential substance of paper 47-43, "Modern Car Equipment for New York City's Subway System," presented at the AIEE winter meeting, New York, N. Y., January 27–31, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

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Figure 1. An artist's idea of the general perspective of the new car

the short interval involved in braking, any increase above the 3.0 miles per hour per second rate would be even less effective than a corresponding increase in acceleration.

REDUCTION OF NOISE

The specific details of our efforts toward noise reduction in these cars are as follows:

1. *Use of Rubber.* Rubber is used at important points of contact and should insulate the car body effectively from the high frequency vibrations, and reduce impact forces.

2. *Motors and Gears.* Motors are truck-mounted, being hung on the transom and connected to a separate gear unit through a flexible coupling. This reduces the unsprung weight and prevents the transmission of road shocks from the wheels and axle to the motors.

High angle helical gears running in oil were selected for quietness and low tooth loading. Motors and gear units are equipped with antifriction bearings throughout, so that accurate clearances can be maintained. This is very important because of the high rotor speeds and small air gaps.

3. *Lateral Shock Absorbers.* The older subway cars had a tendency to nose causing lateral motion of the car body when certain factors reached a resonant stage. Changes in basic truck design and a lateral shock absorber between the truck bolster and the side frame have been adopted, eliminating the striking of the bolster against the side frame.

4. *Center Plates.* Conical center plates on bronze bearings and in an oil bath will reduce the slap between the body and the truck center plates. This construction also will reduce the force required to turn trucks on curves, resulting in lower flange pressures of the wheel against the rail, thereby reducing squealing and increasing the life of both the wheel flanges and rail heads.

5. *Dynamic Braking.* The use of dynamic braking will reduce the number of shoe applications to the wheels and also the shoe pressures. As explained in the consideration of deceleration, only about six per cent of the total work required to be done in stopping the train will be done by the brake shoes, thus eliminating most of the frictional noises between shoes and wheels.

6. *Brake Cylinders Mounted On Trucks.* Brake cylinders have been mounted on the trucks, thus avoiding the use of foundation brake rigging on the body.

The noise level of operation within the subway structure with present equipment averages 89 decibels. The elimination or reduction in magnitude of the above fac-

for the higher rates of acceleration to provide the small current increments required to keep it smooth, and also to avoid the difficulties encountered in transition from series to parallel at the high rates. A saving of approximately four per cent to five per cent in power can be made by using series-parallel control.

3. *Comfort of Passengers.* With large numbers of standing passengers and with others on longitudinal seats and on seats facing in the opposite direction of travel, we felt that rates accelerating in excess of 2.5 miles per hour per second were too high.

4. *Relatively Small Increase Obtained.* Analysis of typical speed time curves indicated that in stepping up the acceleration rate there is a saving of 36 seconds in one hour of running, which is not worth the added cost and possible discomfort to passengers. From 3 miles per hour per second up, the law of diminishing returns goes to work with increasingly poor results, as far as scheduled speeds are concerned.

Deceleration received the same consideration, and a dynamic rate of 3 miles per hour per second for seated load conditions was selected for the following reasons.

1. *Increased Size of Motors Required.* Higher braking rates would necessitate larger motors, involving additional costs and weights.

2. *Change of Control.* Dynamic braking was not carried to zero resistance on the new equipment because of the large number of steps required in the lower speed ranges. It starts to fade at about 10 miles per hour, at which time air is applied and used to the final stop. The amount of work left for the air brake is a very small percentage of the total.

3. *Comfort of Passengers.* A maximum rate of 3 miles per hour per second is maintained because of the signal control, and where full load conditions reduce the dynamic rate sufficient air is used to supplement the dyanmic braking in order that the rate the operator is calling for is maintained.

4. *Relatively Small Increase in Schedule Speeds.* Here also the law of diminishing returns applies. Because of

tors will have a noticeable effect in lowering the noise level.

OTHER FEATURES OF THE NEW CARS

Four motors per car, one per axle, were selected so that accelerating and braking loads would be distributed evenly and kept within the normal adhesion factor of wheels and rail.

Thermostatic control of heat will provide more uniform temperatures and utilize the body heat of passengers during crowded periods.

Eight 10-inch horizontal fans will provide a much better distribution of air than the five fans blowing vertically in the old cars.

The car interior is designed for easy cleaning. All surfaces were kept as smooth as possible, and corners were coved and rounded. Exhaust ventilation will improve cleanliness of the ceiling. Dynamic braking will reduce the amount of iron dust from brake shoes and wheels. Completely sealed gear cases will eliminate the grease drip which is so objectionable.

Plastic seat coverings, impervious to all common acids and alkalies, and able to take the daily wear without becoming shabby will upholster the cushions and backs.

Narrower side posts and recessing interior finish under window sills provided wider aisles as well as longer seat cushions. Wider door openings will facilitate the interchange of passengers.

A New Single-Side-Band Carrier System

B. E. LENEHAN
ASSOCIATE AIEE

This new method of single-side-band generation is based on the frequency addition principle. Apparatus consists of linear modulators combined with wide-range phase-splitting circuits to produce the signals.

ON POWER LINE conductors for communication, the present range of frequencies is from 50 to 150 kc. Use of low frequencies involves losses in the power equipment connected to the lines and coupling difficulties; higher frequencies involve appreciable radiation and conflict with aircraft radio beacons. To meet increasing demand for available frequencies a better solution than extending the frequency band may be the use of the single-side-band system, requiring about half the frequency range per channel of other systems.

When a signal wave is resolved into its component frequencies, a voice signal is found to have components from 150 to 3,000 cycles. Transferred to a higher frequency, the signal consists of the normal frequency, a group of higher frequencies near by, called the upper side band, and a similar group of lower frequencies, called the lower side band. For amplitude modulation there is one frequency in each band for each frequency in the signal; for frequency modulation there may be more. Each frequency component occurs at least twice, so that the signal occupies at least twice as much space as in the low-frequency state. The single-side-band system transmits only one group of these frequencies, each frequency being equal to the carrier frequency plus or minus the frequency of the signal component.

HISTORICAL

Of the two methods of producing a single-side-band signal, the most used system, described in 1915, consists of eliminating all components of the amplitude-modulated signal except the desired side band by using filter circuits.[2–5] It was not considered suitable for general power line use because of the number of circuits to be retuned to change frequency and the difficulty of designing and building adjustable filters.

The other system consists of adding the carrier signal frequencies together to produce the single-side-band frequencies. A system of this type was invented in 1925 by R. V. L. Hartley.[6] Later an improved form of this

Essential substance of paper 47-112, "A New Single Side Band Carrier System for Power Lines," presented at the AIEE North Eastern District meeting, Worcester, Mass., April 23–25, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

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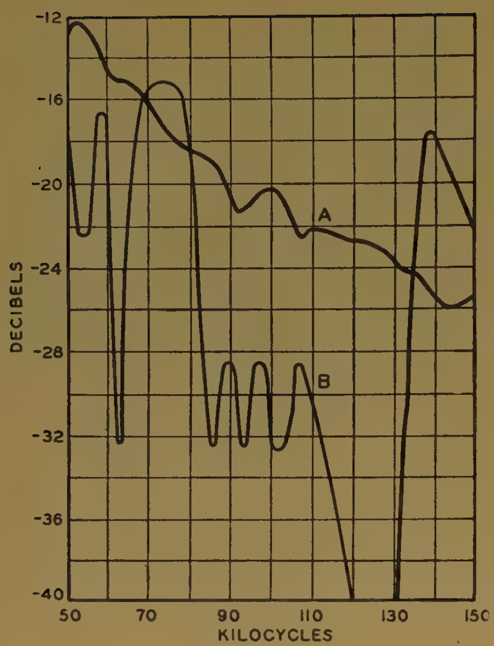


Figure 1 (left). Typical powerline transmission characteristics

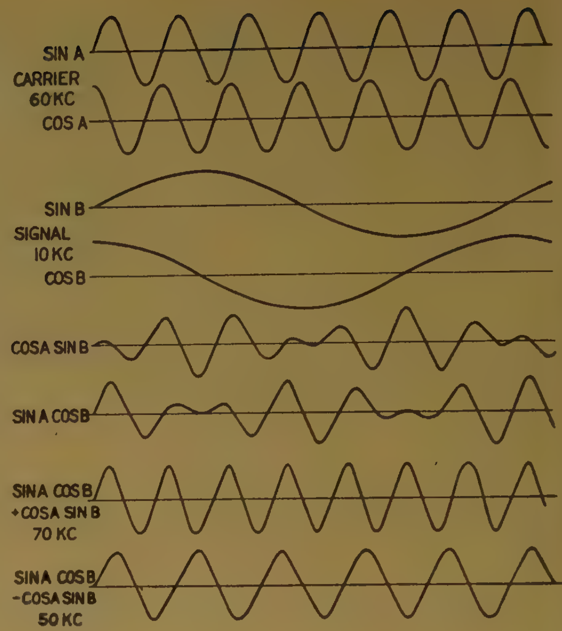


Figure 2 (right). The frequency addition method

The first two lines represent carrier current; the next two, signal currents; the fifth and sixth, the two modulator outputs; and the seventh and eighth, the sum and difference frequencies

circuit was used by Byrne as part of a polyphase broadcasting system.[7]

APPLICATION

The fact that power line carrier communication uses a channel designed for something quite different means that any impedances added to alter its characteristics will be of large physical size and corresponding cost, and also that the presence of other equipment must be tolerated. Figure 1 shows transmission curves at different frequencies for two such lines. Line A presents no problems, line B has two wide and one narrow channel which might be used, with one channel the second harmonic of another, an undesirable allocation of frequencies. Equipment for such lines must be continuously adjustable in frequency, which is the basis on which this system was developed.

NEW SYSTEM

The method described in this article uses a network of nine circuit elements to produce two currents very close to 90 degrees apart, with the main errors in the magnitude. Circuit theory indicates that at any one time only one of these conditions (90-degree phase or magnitude equality) can be met over a range of frequency. Correct phase displacement was selected as the preferred condition, and a close approximation to equal amplitudes was secured.

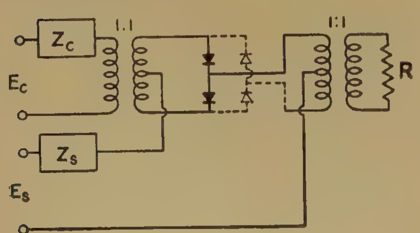


Figure 3. Schematic circuit of a copper-oxide ring modulator

THE MODULATING SYSTEM

The amplitude of an a-c wave commonly is expressed as the sine of an angle proportional to time. Each low-frequency term must be added to or subtracted from the carrier-frequency term to produce the required single-side-band output. The trigonometric formula for the sine of the sum or difference of two angles is

$$\sin (A \pm B) = \sin A \cos B \pm \cos A \sin B$$

As the cosine terms are 90 degrees out of phase from the sine terms, 2-phase currents of both carrier and signal frequencies are needed, and they must be multiplied together in pairs and added (Figure 2).

Two-phase currents of the signal and carrier frequencies are produced by phase-splitting circuits which produce 90-degree displaced outputs of closely equal magnitudes. These outputs are multiplied together by two copper-oxide modulators. Each of them consists of four rectifier disks connected in a ring, all facing the same way in series (Figure 3). One current, the carrier, is larger than the other, and its presence changes the resistance in the circuit of the other current. If the total signal circuit resistance is inversely proportional to the voltage output of the carrier phase-splitting circuit, the output current will be proportional to the desired product. This requires operating the modulator in a manner slightly different from previous practice, but the resulting signals are very free from undesired frequencies.[8,9] Each of the phase-shifting circuits is equivalent to a voltage with an impedance in series. This impedance is nearly all resistance (Figure 3).

Tracing through the signal current path, the circuit consists of the internal impedance of the phase shifter Z_s and the equivalent load resistance $R/4$ in series with a parallel circuit of the two halves of the carrier-fre-

quency input transformer and the two rectifier disks shown in solid lines. These disks are in parallel for the signal and in series for the carrier input, but each circuit is independent and balanced against currents in the other, except for resistance changes in the rectifiers produced by the presence of the carrier current. When the carrier current changes polarity, the dotted disks come into service, and the connection to the output transformer is made to the other end, reversing the output polarity, as it should. The resistance of the rectifier to the smaller signal current is, for the two parallel disks, one half the incremental resistance. For the larger carrier current, the resistance for the two disks in series is twice the usual resistance, or $2e/i$. Operating conditions are chosen such that the total resistance in the signal circuit is inversely proportional to the carrier voltage Ec. The result is that the e–i curve required for linear modulation is closely similar to obtainable rectifier curves (Figure 7).

The schematic diagram is shown in Figure 4. The carrier phase splitter consists of a resistor, capacitor, and mutual inductor in series across the secondary of the input transformer. The voltage across the resistor appears in one branch of the output circuit, and the voltages across the capacitor and mutual inductor, connected to add, appear in the other. A change in frequency affects the voltages across the capacitor and mutual inductor in opposite directions, with the result that their sum varies only over a 25 per cent range for a 4-to-1 frequency range. The resistor branch has an inductor and capacitor added to the output side, and the inductor–capacitor branch has a resistor similarly added to make the internal impedances of the outputs equal at all frequencies. The voltages across the capacitor, inductor, and resistor at 80 kc are in the ratio 1:1:2. Over the range of 50 to 150 kc, the current in the two output branches will be balanced within 15 per cent and be 90 degrees apart. The actual outputs will be closer together, as some saturation will take place in the high-voltage branch when the modulator is operating.

The signal phase splitter has an additional parallel resonant circuit added which increases the voltage in the resistor side by drawing out-of-phase current through the reactor and capacitor which are added to equalize the impedances. This voltage increases as the edges of the band are approached and improves the balance. The reactance introduced by the addition of this circuit is opposite in sign from the rest of the circuit and permits equalizing the output voltages at the edges of the band by varying the design proportions of the different elements. This circuit was designed for the operating range of 150 to 4,200 cycles and at the same time to provide the attenuation needed between the power level of the usual telephone line and the best operating level for the modulator. In Figure 5 the performance obtained with the modulators replaced with 300-ohm resistors is given with 10 volts applied to the phase-splitter input over a wide range of frequency. E_1 and E_2 are the two output voltages, and θ the angle between them. E_2 is repeated at 1/10 scale to permit the values at extreme frequencies to be plotted. The input admittance of the circuit is similar to the curve for E_2 and, when the proper input impedance-matching transformer is used, the outputs E_1 and E_2 are practically constant over the designed range. It is possible to have equal voltages at four frequencies, and 90-degree phase displacement at three frequencies in the band. The reactors used have a Q value of about 18. More complicated circuits do not seem to add enough to the performance to warrant their use.

The carrier frequency is suppressed by passing direct currents through the two signal paths. Each adjustment controls a carrier current that is 90 degrees from the other, so zero can be reached by alternately adjusting the controls similar to balancing an a-c bridge for magnitude and phase. Without these adjustments, the rectifiers normally will be balanced closely enough to reduce the carrier about 20 decibels below maximum signal. With them -72 decibels was obtained. The limitation was in the sensitivity of measurement. Balancing for the undesired side-band elimination is accomplished with the taps on the transformer secondary resistors. Figure 6 shows the modulation characteristic from line input to amplifier grid input. It is linear up to the point where the output voltage is high enough to cause conduction on one of the idle rectifier disks through the idle half of the output transformer winding. Here a

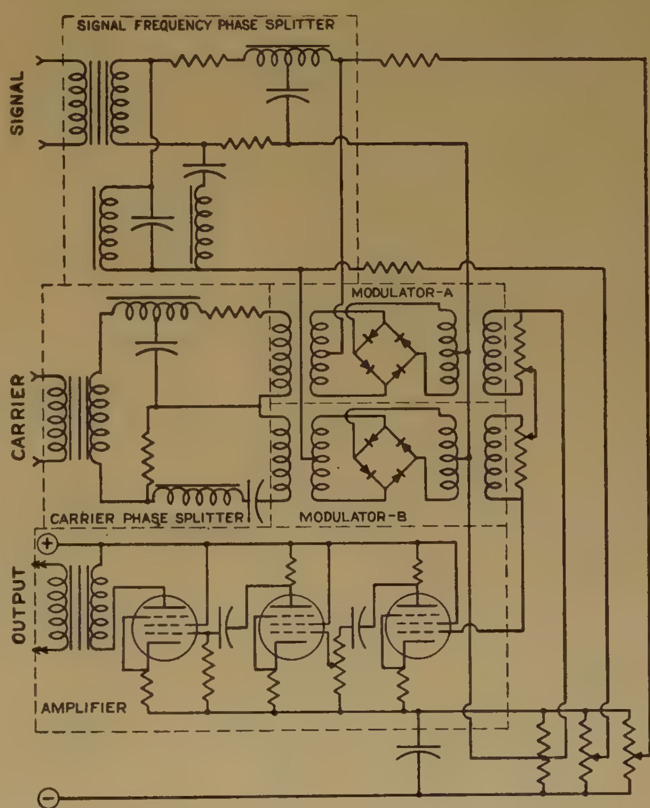
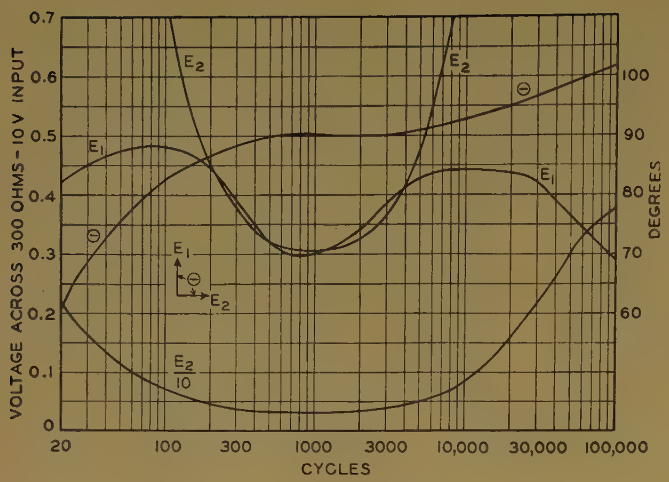


Figure 4. Circuit arrangement of single-side-band transmitter



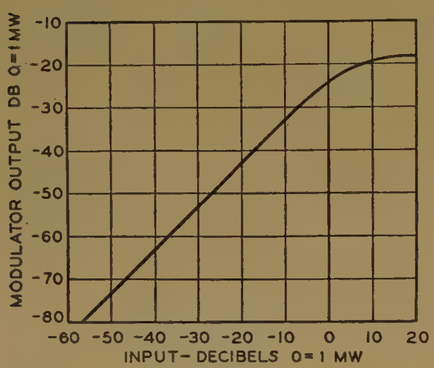


Figure 5 (above). Performance of signal - frequency phase splitter over an extended range of frequency

Figure 6. Modulator performance from signal input to amplifier input

limiting action takes place, and some distortion results. Overloading produces some output in the undesired side band. Laboratory tests show less than 4 per cent distortion for the combined transmitter and receiver.

With this modulation arrangement either or both side bands may be produced. The carrier can be added inphase with both side bands to produce amplitude modulation, or it may be added at 90-degree phase to provide a form of phase modulation. Carrier with one side band also is obtained readily, which provides reduced channel width advantages with ability to be received on ordinary amplitude modulation equipment.

The oscillator in any single-side-band system is required to have better than ordinary frequency stability,[10] and the receiving methods used are similar to those used for amplitude modulation.

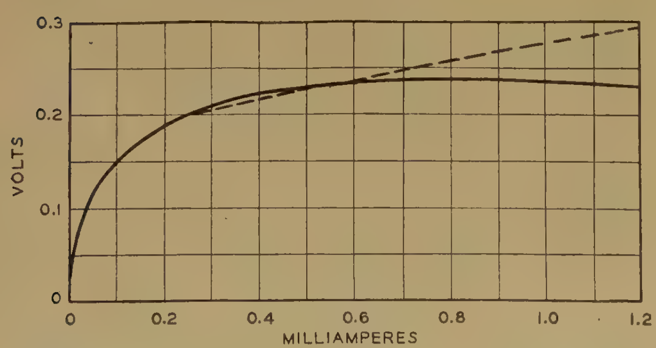


Figure 7. Comparison of required curve for linear modulation (solid) with possible rectifier curve (dashed)

Range up to 0.6 milliampere used in practice

This system normally would be used to transmit a voice band from 150 to 3,000 cycles for telephone or tone-telegraph operation. The performance of the modulator for frequencies above 3,000 cycles is still fairly good, the main result being a larger output of the undesired side band. A simple tuned circuit used in the transmitter can reduce the undesired output to a level at which it would not be noticeable. The modulator thus can handle two channels if one is first converted to a single-side-band signal on 3-kc carrier upper side band, or 6-kc carrier lower side band; or the space above three kilocycles can be used for tone-telegraph control or telemetering signals.

When sending and receiving oscillators are not at the same frequency, the ear perceives sound by a resonance indication, and the positions of the resonances along the frequency scale are shifted sideways a small amount. Since the frequency error is a greater percentage at low frequencies, music sounds as if the instruments were out of tune when the difference is 2 to 5 cycles. Speech requires a 20-cycle difference before anything wrong is noticeable; in fact, a difference of 50 cycles probably would be accepted without question. However, speech is still intelligible, though unnatural, even at 200 cycles difference. Twenty cycles is considered a satisfactory limit, as tone-signaling equipment requires channels wider than 40 cycles to transmit telegraphic side bands.

For equipment operating on these principles the standard 19-inch panel arrangement is used, permitting older type transmitters to be used as power amplifiers if conversion to single side band becomes necessary because of crowded frequency conditions.

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Interconnected System Operation, Planning, and Performance

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A practical summarization of the factors affecting interconnected operation is presented which shows that the interest of management, adequate organization, careful planning, and correct procedures are the essential elements contributing toward successful interconnection.

SUCCESSFUL operation of interconnected systems, that is the realization of as many as possible of the potential benefits of interconnection, is dependent primarily and at all times on a desire for such success by the management of each of the interconnected systems. This should be expressed, positively, and forcefully, and be evidenced by a continuing interest in the resulting economies.

Successful interconnected operation is further dependent on

1. Adequate organization.
2. Careful planning.
3. Correct procedures.

ORGANIZATION

A good form of organization for a group of interconnected systems is through an operating committee with membership made up of individual representatives from each interconnected system.

The operating committee can be recognized contractually, or informally established by group management accord. Each operating committee member, or company representative, preferably should be a responsible member, if not the head, of the operating department of his system. The management of each system should delegate to its committee member sufficient authority to make decisions and commitments for his system with respect to operating procedures affecting the interconnected group. Committee members should not be "instructed delegates" and should make decisions in meetings, rather than delay pending further discussions "back home" with management.

In addition to the operating committee a co-ordinating technical staff is essential, composed of one or more individuals, devoting their entire time and effort to the interconnected operating problems of the group. The size and scope of activities of such a staff will vary for different conditions, but at least one individual should be named for this function. This individual, with any appropriate title, such as "co-ordinating engineer," or "interconnection manager," and any assistants on his staff, should derive authority from, report to, and advise with the operating committee.

In the history of most of the successful interconnected operating groups, it usually is found that some one individual of strong character and personality, absolutely impartial, well qualified, and well liked by all his associates, has taken a predominant part in the activities, and to a large extent can be credited with the success of the operations. In planning any new organization, it well might be the best first step therefore, to select such an individual to head the technical staff, and let this individual actively assist in all further steps of organization and planning.

Another important step in organization is the establishment of fundamental policies by management to guide the functioning of the operating committee and the technical staff. The committee and staff very often can assist management in this by suggesting definite principles which must be stated in such a way that they will not jeopardize that freedom of action in the application of these policies to operating procedures that is so necessary. There should be agreement at the outset on fundamental principles and bases of sharing the benefits of interconnected operation, not in detail, but in broad general terms, and then all efforts should be bent toward realizing the maximum possible benefits, rather than continually trading for advantageous position.

PLANNING

Contractual relationships should be formed so as to permit and promote the maximum utilization of physical facilities and optimum operating efficiencies, rather than to permit arbitrary limitations to be placed upon such operations and uses by agreements.

Co-ordinated planning of the physical facilities is as important as planning the operating organization in the effect on over-all results. Major interconnection physical facilities, such as transmission lines, transformer banks, and switching, can be planned with sufficient flexibility or with provision for future modification as most probably will fit any desired interconnection services

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Full text of a paper presented at the conference on interconnected systems at the AIEE winter meeting, New York, N. Y., January 30, 1947.

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that conceivably can be justified under the fundamental economics of the situation, or they can be designed for one or a limited number of interconnection services and thereby limit their usefulness under changing conditions.

Auxiliary physical facilities such as communication, telemetering, and automatic control equipment also require careful planning. One of the greatest aids to co-operation is understanding and knowledge. Silence or secrecy breeds misunderstanding and suspicion. Communication channels should be available, between operating department headquarters offices as well as main dispatching offices of neighboring or adjacent systems, and of such a character as will encourage frequent and liberal use of these channels. Planning communication facilities for these uses is often difficult because of the long distances and high costs. For carrier channels there are unusual application problems with repeaters and wire line extensions. In my experience, inadequate planning of such communciation facilities has always been the result of "trying to get by" with the minimum of facilities in order to hold down the cost—a worthy cause in itself—but not worth the resultant handicaps to successful operations from the start.

Telemetering to each dispatching center of the interchange on each of the major tie lines between that system and others is a prime requisite. Unless a dispatcher knows what is taking place on his interconnections, and the best way for him to know is to see, there is little he can do safely and be sure that his efforts are co-ordinated with those of others. For the same reason, telemetering of the output from all the larger or more important generating sources on a system to the dispatcher's office is most desirable, as it gives him the information that permits him not only to operate his own system most efficiently, but to know at all times what margins he is working with, to what degree he may be able to assist through the interconnections for trouble elsewhere, or to what degree he may be borrowing trouble by encroaching on the capability of the interconnections in the event of an emergency on his own system. Ignorance may be bliss, but every dispatcher I ever have met on the job was much happier with such telemetering available and working than without it.

Automatic equipment for control of tie line loads and frequency is indispensable on each major system of an extensive interconnected group, particularly where there are ties of limited capacity between systems, in order to realize maximum operating capacities and increase the dependability of the interconnections. It is almost indispensable on each system of any interconnected group, if for no other reason than to indicate that, as a token of good faith, each system really is willing to do its share of the common burden of frequency regulation, or as a means of "living up" as closely as physically possible to prearranged interchange schedules, when such schedules are the only practicable or manageable way of operating a complex or extensive interconnected group.

Planning, as well as the application of automatic control equipment, calls for a detailed familiarity with the operating characteristics and capabilities of the systems concerned as well as a highly specialized knowledge and experience with the application of this type of equipment. For flexibility, automatic control equipment should include such features as

1. Ability to operate under different types of control, including frequency control when the system is isolated, flat tie line control without regard to frequency, and tie line bias control where recognition is given to both the interchange and the frequency in determining the direction and magnitude of corrections.

2. Ability to control the interchange on any tie line or group of tie lines or the net interchange over all interconnections.

3. A wide range of adjustability in bias settings.

4. A wide range of adjustability in the response of generating units to the correcting impulses.

5. Ability to control frequency or interchange with any one or any combination of the generating units and plants suitable for this service.

PROCEDURES

Meetings of the operating committee should be held frequently until established procedures are worked out and other adjustments are completed, and regular meetings should be held possibly at monthly intervals thereafter. It is important that committee members meet as a group at regular and fairly frequent intervals, regardless of how often they may see each other individually, to insure maintenance of that spirit of unanimity that is essential to success.

The time when it would appear there is little of importance to discuss at a regular meeting is often that at which some real progress can be made through group thinking and discussion on worth-while improvements and new ideas.

Definite written fundamental principles and practices should be adopted with respect to operations affecting the equities of the individual systems.

In general, the co-ordinating group or technical staff should act as a clearing house, to keep all members of the operating committee fully informed on all matters of general interest affecting interconnected operation. Records of loads, capabilities, reserves, storage in reservoirs and coal piles, maintenance schedules, and diversities, should be kept for the information of the group, as an aid in forecasting future requirements and operating programs. Yearly or 2-year operating programs, including co-ordinated maintenance schedules, should be prepared in advance and revised as often as necessary. Methods for interchange scheduling and accounting including the effects of losses should be agreed upon. Records of equipment and manpower pools should be kept up to date for possible use in emergencies. Standard procedures should be established covering many of the operating practices, such as interconnection switching rules both under normal and emergency conditions.

Co-ordinated tests of governors and control equipment should be arranged and the results jointly studied to arrive at optimum adjustments and types of control for all operating conditions.

Without attempting to name all of the other desirable activities it might be simply stated that the most essential component for success is a straightforward, completely fair, and business-like approach in every procedure.

A Vacuum Tube for Acceleration Measurement

WALTER RAMBERG

Though not perfected for field use, the vacuum tube acceleration pickup has several peculiar advantages which will facilitate many types of acceleration experimentation. These potentialities encourage further development of the tube.

THE USE of the deflection of electrodes in a vacuum tube for the direct measurement of mechanical quantities is not new. The vacuum tube acceleration pickup was developed to obtain a pickup with an output large enough for recording accelerations on airplanes in flight without the use of amplifiers between the pickup and the recorder.

Applications of the tube are limited by its peculiar advantages and disadvantages relative to other acceleration pickups. High output, high natural frequency, linearity up to large accelerations, and operation over a wide range of temperatures are the prime advantages of the tube; unpredictable zero drift, zero shift under impact, 15-minute warm up time, high current consumption, and the need of a filter to remove natural frequency response constitute the disadvantages of the tube.

CONSTRUCTION

As shown in Figure 1, the tube contains two elastically mounted plates P_1 and P_2 with a fixed cathode C between them. Acceleration in a direction normal to the plane of the plates causes a displacement of the plates relative to the cathode. This increases the current between one plate and the cathode and decreases that between the other plate and the cathode. The change in current will be proportional to the component of acceleration normal to the plane of the plates for frequencies low compared to the natural frequency of the plates as an elastic body. It may be recorded with an electric bridge circuit.

The use of symmetrically placed twin plates makes the output of the tube relatively insensitive to fluctuations in the total electron current from the cathode. The indirectly heated cathode is rigidly mounted in the two mica plates M. These, in turn, are built into a rigid box by the transverse bars B_1 to B_4. The box is held in the base of the tube by the four vertical pins B_5 to B_8. The plates P_1 and P_2 are formed from thin sheet metal to reduce their heat capacity and hence the warming up time of the electrodes. The plates are mounted on slender vertical rods R_1 to R_4 to give them the desired flexibility normal to their plane. The rods are welded to two of the transverse bars, bars B_3 and B_4, holding the mica plates together. Electric connection is made to the vertical pins B_9 to B_{12} by connectors between the ends of the transverse bars and the tops of the vertical pins. The frequency range of the pickup may be controlled by the proper choice of diameters and length of the wires used in the supporting structure. The sensitivity may be increased by decreasing the natural frequency or by decreasing the spacing between plates and cathode.

USE

Circuit. Figure 2 shows the Kelvin double bridge circuit used with the tube which reduces the effect of changes in contact resistance in the plate circuit. A low pass filter is inserted ahead of the recording galvanometer to eliminate oscillations at the natural frequency of the plates. An ordinary loctal socket is used for connecting the leads to the pins at the base of the tube. This facilitates the replacement of tubes and eliminates the need for soldering leads to the pins.

Attachment to the Structure. Special care must be taken to clamp the tube to the structure in such a man-

Essential substance of paper 47-108, "The Measurement of Acceleration With a Vacuum Tube," presented at the AIEE North Eastern District meeting, Worcester, Mass., April 23–25, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

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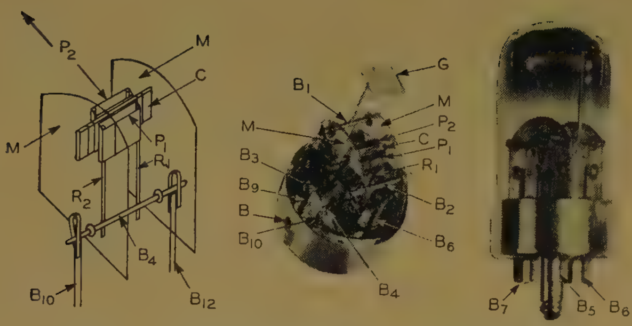

Figure 1. The vacuum tube acceleration pickup

ner that it will experience the same acceleration as the structure. To accomplish this the attachment must be rigid enough so that the fundamental frequency of the tube, when attached to a rigid structure, is high compared to the fundamental frequency of about 800 cycles per second of the plates in the tube. At the same time the clamping force must be distributed over the tube to prevent breaking the glass envelope during clamping. Figure 3 shows two clamps which have been used.

Calibration. It is desirable to calibrate the tube and its associated electric circuit by subjecting it to a known acceleration and recording the output. If accelerations of not more than 10g are to be measured, the calibration is conveniently made by subjecting the tube to an acceleration of 2g in the earth's gravitational field. This is accomplished by first mounting the tube so that the plates are horizontal and then rotating the tube about its horizontal axis until the plates are again horizontal.

In some cases a known change in acceleration is recorded as part of the test itself and then used for calibration of the rest of the recorded data. Where the accelerations to be measured are much larger than 2g, it is desirable to calibrate the tube with a larger output delivered to the recorder. This is obtained either by imposing larger accelerations on the tube or by increasing the sensitivity (lowering the attenuation) and calibrating at 2g.

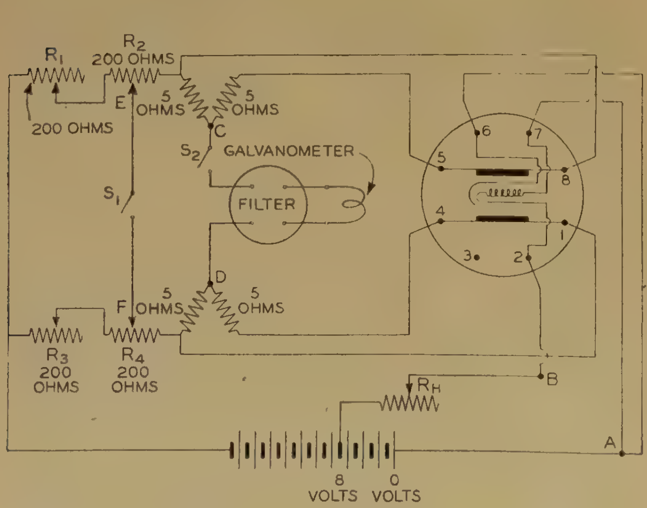

Figure 2. Electric circuit for use with the pickup tube

In calibrating the tubes, it is assumed that the calibration factor is constant for the entire range of acceleration to be measured. Recent tests of tubes subjected to centripetal acceleration on a spinning table showed substantially linear output up to accelerations of 160g.

The spinning table also was used to determine the maximum steady accelerations which can be sustained by the tubes without permanent damage. In tests of a few tubes it was found that the zero shifting exceeded five per cent of the maximum applied acceleration when this acceleration was greater than 160g. (Zero shift is probably caused at least in part by excessive bending stresses in the slender rods supporting the plates.) The output was nearly proportional to acceleration up to the point at which one of the plates made contact with the cathode (between 240g and 340g).

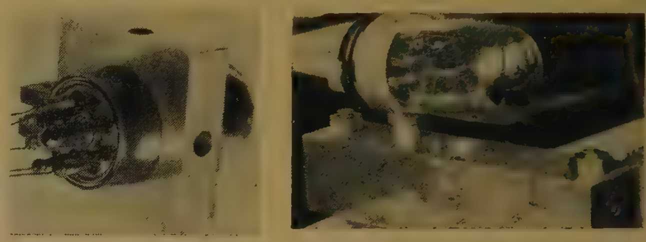

Figure 3. Tube mounted in square edge clamp and in ring clamp

The response of the tube to acceleration parallel to its plates has been measured on a shaking table and more recently by centripetal acceleration on the spinning table. The output at an acceleration of 200g was equivalent to less than 10g for any direction of the acceleration in the plane of the plates.

It was found that zero drift in the order of plus or minus 1g in a few minutes is unavoidable and of an unpredictable nature, but that the drift tends to decrease with the age of the tube.

POSSIBLE IMPROVEMENTS

It appears that further development is needed to make the tube a satisfactory instrument for general flight measurements. The use of a directly heated cathode probably would be an over-all improvement leading to greatly reduced power consumption, shorter warm up time, a reduction in size with a resultant increase in frequency and in range, and a decrease in zero drift.

Mechanical stops to limit the displacement of the plates to a value corresponding to approximately 200g would prevent excessive bending of the plate supports by impacts of short duration. This would reduce zero drift. The use of a metal envelope might reduce breakage during clamping.

Sunspots and Telegraphy

C. H. CRAMER
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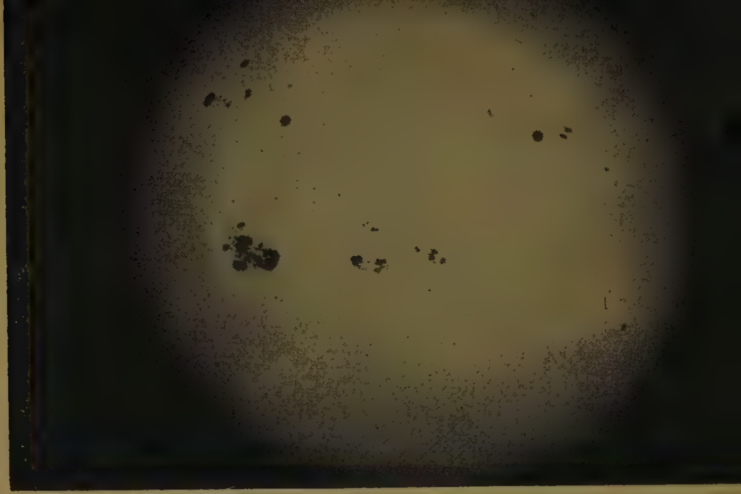

Mount Wilson Observatory photos

(Above) The sun and sunspots, August 12, 1917, and (left) closer view of the granuluar surface of the sun

Beyond the facts that they recur in well-defined cycles and that they affect certain of the earth's latitudes more than others, little but theoretical knowledge exists about the nature of sunspots and the sometimes concomitant magnetic storms. However, almost inadvertently, modern telegraph systems are being immunized against them by such innovations as carrier currents and radio relay systems which avoid the effects of earth-current disturbances.

PLAGUING domestic and international communications and disrupting transatlantic air transportation schedules, the severe magnetic storms* in February and March 1946 were emphatic reminders of nature's inexorable laws. Detailed factual knowledge of the unfathomed processes which combine to produce these phenomena still is largely unassembled, although theorization and speculation have not been meager. The source of the magnetic storm has been established as 93-million miles distant, at the center of our solar system, and the cause definitely is related in some manner to the well-known sunspots. It also is known that, coming after a period of relative inactivity, the 1946 storms were but the vanguard of disturbances to be expected during the next several years. Since the initial storms, sunspot activity has been increasing, with spots of record size on two occasions and several periods of terrestrial disturbance.

No record of any observation of the darkened areas on the sun now known as sunspots has come down from ancient times. The earliest study of sunspots appears to date back to 1609, the year Galileo constructed the first astronomical telescope. Through his observations of sunspots and their apparent motions, he established, if only to his own satisfaction at the time, that the sun turns on its axis. By 1750 observations were being made with some regularity, and beginning in 1849 data were recorded systematically. Today, from photographs of the sun at various observatories, accurate day-by-day information is obtained of the number, size, and position of spots on the hemisphere of the sun visible from earth.

THE SUNSPOT CYCLE

Eventually it was discovered, as is true of so many of nature's phenomena, that sunspots occur in rather well-defined cycles. When the relative sunspot numbers are plotted, as in Figure 1, it is evident that maximum activity recurs regularly at intervals of approximately 11 years. Between the peaks are valleys of minimum activity. Another fact apparent from the graph is that since 1848 alternate 11-year peaks have been of somewhat greater magnitude than the intervening peaks. Other periodicities are present, some of which have been disclosed only by complex mathematical analysis.

From a casual inspection of the graph, it might be concluded that the next peak will occur near the middle of 1948 and that it will be of smaller magnitude than the 1937 peak. While it is as certain as tomorrow's sunrise that a peak will occur within the next several years, with accompanying disturbances on the earth, authorities have reached varying conclusions as to its

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* The term, "magnetic storm," is used here in a general sense to include the aurora and radio propagation and earth-current effects, as well as disturbances of the earth's magnetic field.

exact time and relative magnitude. The predictions of the time of occurrence, arrived at by different methods of analysis, range from early 1948 to 1951. Some authorities expect a low maximum, consistent with recent cycles; others predict a peak of considerably greater magnitude than the last. Support for the early high-peak predictions is found by some in the rapid rise in sunspot activity during and since 1945.

TERRESTRIAL PHENOMENA

The terrestrial effects produced by, or at least in some way coincident with, sunspots and which occur in similar cyclic patterns, are the most important phase of the phenomena to the workaday world. A definite relationship has been established between the sunspot cycle and auroral activity, variations of the earth's magnetic field, earth currents, and radio propagation effects, the disturbances or variations in these reaching a maximum during the sunspot peak. All of these effects are magnified highly during the great magnetic storms.

Attempts have been made and still are being made by a host of investigators to correlate the sunspot cycle with a wide variety of terrestrial phenomena and activities in addition to the more direct electrical and magnetic effects. Similar and related periodicities have been claimed or suggested in such diverse fields as weather, plant and animal life, periods of prosperity and depression, market indexes, human behavior, and the course of world events. The degree of validity of the numerous alleged relationships probably varies as widely as the types of phenomena involved. The following discussion will be confined to the well-established electrical and magnetic effects, particularly to severe storm conditions.

DISTRIBUTION BY LATITUDE

Sunspots occur principally in the solar zone between 10 and 30 degrees north latitude and in the corresponding south-latitude zone. The larger the spot or group of spots, the greater is the probability of an accompanying storm, although size alone does not seem to be the determining factor. Thus far, solar photographs disclose no distinctive differences between spots that produce storms and those that do not. In each case, they have the appearance of irregular darkened areas which have been described as resembling vortexes in the gaseous outer layer of the sun. This suggests that spots which are coincident with storms are accompanied by some other solar activity. Some evidence is advanced for a relationship with chromospheric eruptions or solar flares, which are associated almost exclusively with sunspots and at times extend immense distances out from the sun.

THE PHYSICS OF THE DISTURBANCES

Whatever its exact nature, uncertainty also exists about the manner in which the solar activity is transmitted across 93-million miles and translated into various disturbances of terrestrial normality. The explanation most frequently heard is that streams of corpuscles or charged particles are projected out into space; another suggests that some form of radiation or ray is involved. If it is assumed that the earth is most likely to be in the path of corpuscles transmitted from areas at or near the sun's central meridian, then it appears that appreciable time elapses before the incidence of terrestrial effects. Present indications are that a magnetic storm follows within one or two days after passage of the related spot across the meridian. As the solar energy approaches the earth, it apparently is influenced by the earth's magnetic field and directed toward the magnetic poles, producing effects in the earth and the earth's atmosphere, varying from maximum near the poles to zero or at least minimum in the equatorial region. Theory, substantiated by radio propagation tests, holds that ionization of the ionosphere in the affected zone is distorted and increased, causing the several reflecting layers to vary erratically in height, or perhaps at worst to disappear, so that radio waves are absorbed rather than reflected. These disturbances are most pronounced in the short-wave spectrum, sometimes resulting in complete "black-outs," although under severe conditions there may be some degree of disturbance to all radio transmission except on short-distance circuits.

Obliged to depend more completely upon theoretical considerations, scientists account for the other effects of magnetic storms by the hypothesis that, along with increased ionization, forces exist which drive the ions in drift currents of enormous total magnitude encircling the earth. It follows that these currents in turn alter the earth's magnetic field, produce the aurora, and induce the abnormal currents in the earth's crust known as earth-current storms.

Abnormal earth currents are the phase of the disturbance directly concerning the operation of wire communication systems, particularly normal landline d-c telegraph circuits and ocean cable circuits which utilize the earth as a return path for the signaling currents. Any such circuit forms a shunt to the paralleling portion of the earth, so that a part of the earth current may be diverted to the wire. In severe storms, with the absence of corrective measures, transmission on earth-return circuits may be blacked out at times just as completely as radio transmission.

FREAK CURRENTS ON CABLES

Earth currents as observed on wire circuits are alternating currents of irregular and varying wave form, apparently containing prominent frequency components from a fraction of a cycle per hour to nearly 60 cycles per hour. Higher frequencies of small magnitude have been observed on ocean cables up to approximately one cycle per second. The character of the disturbance is illustrated graphically by the section of recording meter chart reproduced in Figure 2. This measurement was made on a cable between New York and Bay Roberts, New-

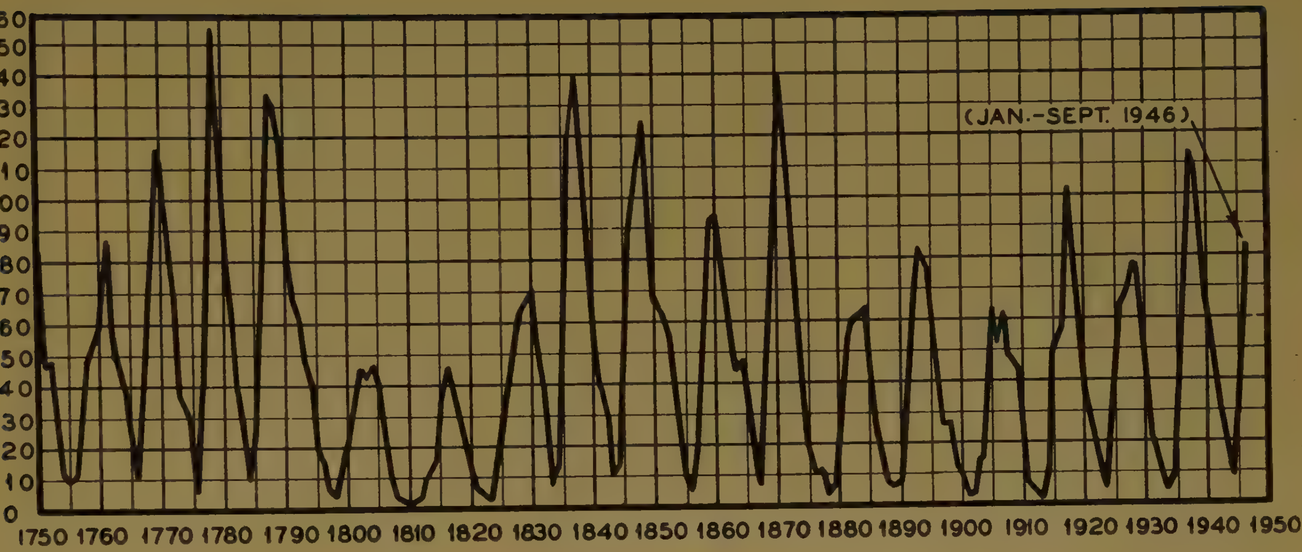
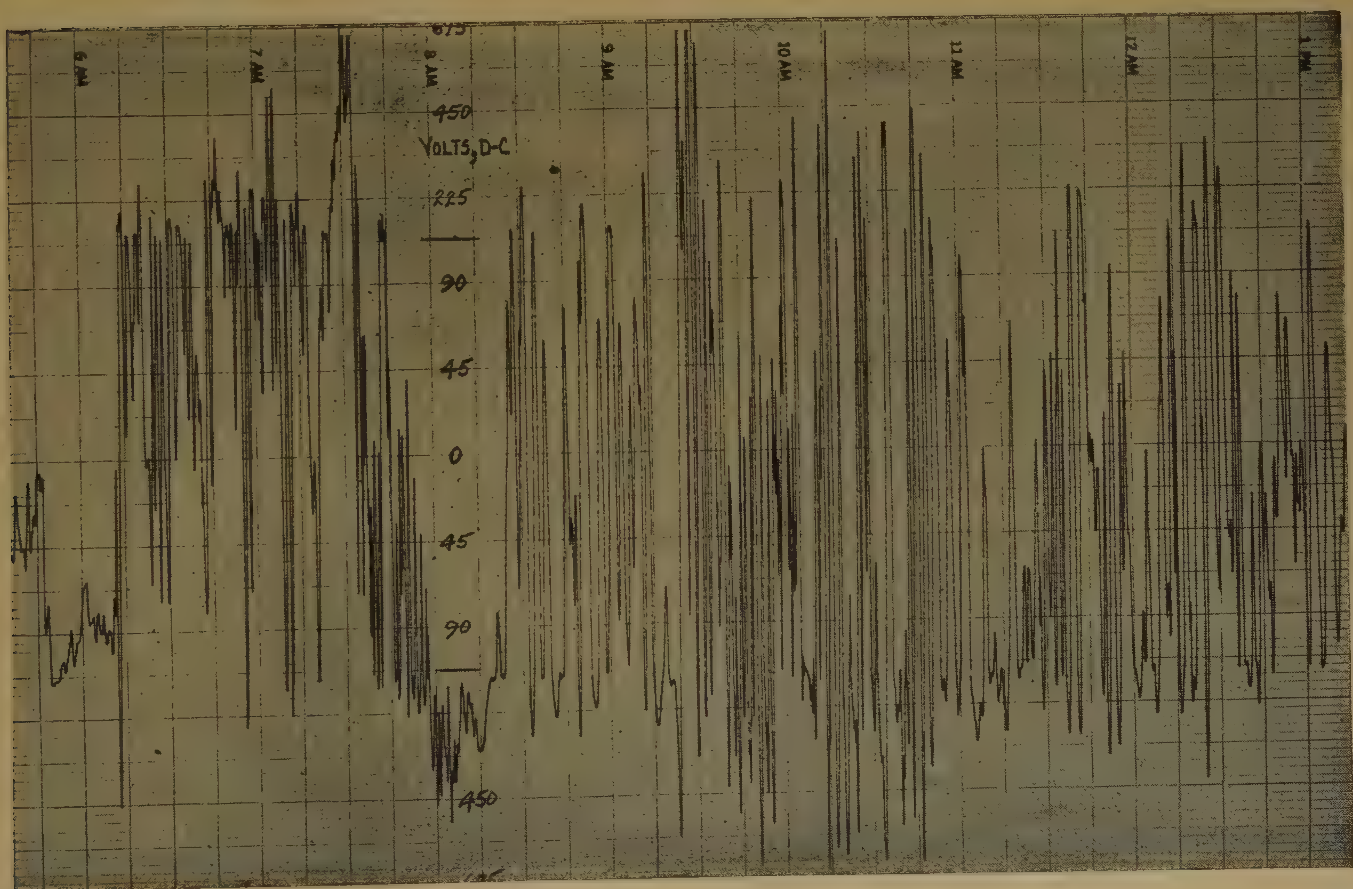


Figure 1. Relative sunspot numbers

foundland. The maximum peak in this instance exceeded 600 volts, which is not unusual on ocean cables in the North Atlantic in severe storms. Voltages in excess of 500 have been observed on landline circuits, which are considerably shorter (that is, between earth connections) than the usual ocean cable.

Observations of earth currents and related operational disturbances in the domestic telegraph system and the ocean cable system of the Western Union Telegraph Company confirm the statement that the maximum disturbance occurs in the higher latitudes. The section of the United States most affected comprises the states along

Figure 2. Earth potentials on a New York–Newfoundland ocean cable during a magnetic storm



or near the northern border. In exceptional storms, however, the disturbance may be felt even in the southernmost states to an appreciable extent. The voltage measured on a wire is maximum when the wire lies in the direction of flow of the earth current and is zero when the wire is at 90 degrees to that direction. Tests on circuits out of New York, N. Y., indicate the direction of flow to be nearly constant, being roughly northwest and southeast in that vicinity.

As has been stated, no appreciable success has been attained in attempts to forecast the time or severity of individual magnetic storms. When a storm has occurred, there is some probability that it will recur generally with less intensity at intervals of 27 days, the effective rotational period of the sun. However, it is more likely that the solar disturbance will have cleared before a rotation has been completed or, if the sunspots are still in evidence, the coincident phenomena which cause the original storm are no longer present in sufficient degree to produce terrestrial disturbance of storm magnitude. Some success is claimed in predicting quality of radio propagation several days in advance, and periods of propagation disturbances a month ahead on the basis of solar, geomagnetic, ionospheric, and propagation data.

IMPROVED EQUIPMENT

Though not introduced primarily for that purpose, many of the advances in telegraphy in recent years have been of a nature to lessen considerably the susceptibility of the service to magnetic storms. In the field of international communications, the principal North Atlantic cable systems in large part have been modernized by the introduction of rugged electronic amplifiers and greatly improved signal-shaping networks or filters. The amplifiers have displaced the delicate electromechanical types of signal magnifiers, thus overcoming the hazard of circuit interruption through damage of terminal equipment by abnormal voltages or currents. The modern signal-shaping networks very effectively reject frequencies below the range required for signal reception, thus substantially excluding earth currents. The cable on which the chart of Figure 2 was obtained operated throughout the storm without interruption.

DETOURING THE SUNSPOT ZONES

Experience during the war years has shown that a large measure of freedom from disturbance in long-distance radio transmission can be obtained by avoiding direct transmission paths which pass through or near the zone of maximum disturbance. This may be accomplished by establishing one or more intermediate relay points between the terminals of a radio circuit. Of pertinent interest is the proposal to establish a trunk equatorial belt radio relay system, with lateral north and south links to the terminals of the various circuits. A more immediate example is the installation of an automatic relay station at Tangier, Morocco, in a New York–Moscow circuit as an alternative to the direct circuit which crosses the magnetic storm region.

At the time of the last sunspot maximum, the domestic telegraph system was operated almost exclusively on a d-c earth-return basis. That condition no longer exists, but the d-c circuits are still of major, although decreasing, importance. Though metallic operation or measures analogous to the signal shaping employed on ocean cable circuits can be utilized, the considerable cost can not be justified, particularly as, in the most disturbed sections of the country, transmission interruptions of importance during business hours from this cause were found to average only three hours per year over an 11-year period. For economic reasons, the sporadic and short-lived nature of the storms thus has relegated the application of specific corrective measures essentially to emergencies. In recent years methods have been standardized in which the more important earth-return circuits in the telegraph network, in effect, are converted to metallic operation as required. Additional relief may be obtained by rerouting circuits through less disturbed areas. Were accurate storm forecasts available, these emergency measures could be arranged in advance.

The rapid expansion of carrier current telegraphy in the past decade to provide additional facilities and improved trunk-circuit transmission is also unquestionably an important development with respect to earth-current disturbances. The extensive multichannel wire carrier installations already in service utilize metallic circuits and frequencies far removed from earth-current frequencies. Immunity to these occasional disturbances, although not a controlling factor in bringing about carrier operation, is, nevertheless, one of the important advantages derived.

RADIO RELAY

The first commercial installation of the radio beam relay system in the domestic telegraph plant is under construction, the forerunner of a projected nation-wide network for trunk telegraph service to replace a large part of the present wire plant. This wide-band transmission system provides, through carrier channelizing methods, a very large number of telegraph channels. The line of sight propagation is independent of both ionospheric and earth-current disturbances.

Western Union carrier telegraph systems already operating and those now under construction or scheduled for early completion, both wire and radio relays, total more than 300,000 channel miles. Beyond this, the complete improvement program, to be carried out as rapidly as practicable, will add about two million channel miles.

Although the advantages of reliable advance information on magnetic storms largely are denied it thus far, American telegraphy faces the coming storm period in a considerably stronger position that it occupied during previous sunspot maxima.

Newton's and Einstein's Relations Between Mass and Energy

J. J. SMITH
ASSOCIATE AIEE

A third and somewhat different approach to the subject of fundamental physical concepts and the related theories is offered to assist engineers in a better understanding of the Newton and Einstein laws and their applications in the field of physics. This is a continuation of the discussion presented in ELECTRICAL ENGINEERING, January 1947, pages 45–66.

THE developments in physics in recent years have excited interest in Einstein's relation between mass m, energy W, and the velocity of light c, namely, $W=mc^2$ which he gave in 1905. Experimental work has substantiated this equation and practical applications are leading to its use by engineers. Since the engineer is more familiar with Newton's equations, it seems desirable to show by actual examples the relation between these and Einstein's equation.

The procedure is to calculate the electromagnetic fields of charges at rest and in motion from Maxwell's wave equation, then evaluate the energy associated with the field. It is found that the part of the energy which does not depend on the velocity gives Einstein's equation and the part which depends on the velocity gives Newton's equation when the velocity is small compared with that of light. The following cases will be studied:

1. Charged particle at rest.
2. Charged particle in uniform motion in a straight line.
3. Charged particle with accelerated motion in a straight line.
4. Charged particle with uniform motion in a circle.

CALCULATION OF ENERGY

The usual method of calculating energy is to find the integral of E^2+H^2 throughout space and thus obtain the total energy. E is the electric field and H is the magnetic field. This is a somewhat involved procedure in most cases. Another method therefore shall be used which gives the results more easily.

The potential V at a point is the work required to bring a unit charge of electricity from infinity up to the point. From this it can be shown[1] that the energy W of a charge e spread on a small surface at any point is

$$W=eV/2 \tag{1}$$

The factor one half comes in because, in bringing up small charges from infinity to the point, the work done on the first element of charge brought up is zero since the potential at the point is zero and the work done on the last element of charge de brought up is $V\,de$ since the potential is substantially the final value and hence the average work is the mean between these two.

While the proof of this theorem as given by Jeans applies only to stationary charges, I also shall apply it to moving charges. I leave the proof of this to others since, as will be seen later, we are more interested in the dimensional relationship between the quantities to be considered than exact numerical relationship. With moving charges, of course, there are both the scalar potential and vector potential. It appears as if the scalar potential still gives the work done in bringing up a unit charge from infinity and the vector potential gives the work done in bringing up a unit current from infinity and evidently since this depends upon the direction of the unit current, it will give rise to a potential with three vector components. I shall not attempt to give an extended discussion of this here, but hereafter will use just the scalar potential.

ENERGY OF A CHARGED PARTICLE AT REST

If there is a sphere of radius a at rest with a charge e, the potential at the surface of the sphere is[2]

$$V=\frac{e}{a} \tag{2}$$

and hence the energy W of the charge from equation 1 is

$$W=\frac{1}{2}\frac{e^2}{a} \tag{3}$$

which for later comparison we will write

$$W=\left(\frac{e^2}{2ac^2}\right)c^2 \tag{4}$$

If in this equation $e^2/2ac^2$ can be identified with a quantity m, which is called mass, then this equation is simply Einstein's equation

$$W=mc^2 \tag{5}$$

ENERGY OF A CHARGED PARTICLE IN UNIFORM MOTION IN A STRAIGHT LINE

If a point charge is in uniform motion in a straight line with velocity u and with a charge e, the potential is

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given by the well-known expression[3]

$$V=\frac{e}{[(x-ut)^2+r^2(1-u^2/c^2)]^{1/2}} \tag{6}$$

In this case the equipotential surfaces are ellipsoids and if a is the major axis perpendicular to the direction of motion, the minor axis in the direction of motion is contracted to $a(1-u^2/c^2)^{1/2}$. To evaluate the energy exactly would require the use of ellipsoidal co-ordinates. However, a usable approximation can be obtained by considering the average of the energy for spheres with radii corresponding to the major and minor axis of the ellipse.

On expanding the above value for V, assuming u^2/c^2 is small so that higher powers than the first may be neglected, we obtain

$$V=\frac{e}{[(x-ut)^2+r^2]^{1/2}}+\frac{eu^2r^2}{2c^2[(x-ut)^2+r^2]^{3/2}}+\ldots \tag{7}$$

which gives as the potential at the surface of a sphere of radius a whose center is at the instantaneous position of the charge

$$V=\frac{e}{a}+\frac{eu^2r^2}{2ac^2a^2}+\ldots \tag{8}$$

In the second term r^2/a^2 is the square of the sine of the angle between the radius vector and the direction of motion of the charge showing as is well known that the energy is crowded towards a plane through the center of the charge at right angles to the direction of motion. We may approximate the contribution of the second term by taking an average value of $\sin^2\theta$ between 0 and π giving 1/2 and thus we may write from equation 8

$$V_{\text{average}}=\frac{e}{a}+\frac{eu^2}{4ac^2}+\ldots \tag{9}$$

using this value of potential the energy corresponding to a sphere of radius a is

$$W=\frac{e^2}{2a}+\frac{e^2u^2}{8ac^2}+\ldots \tag{10}$$

and similarly the energy corresponding to a sphere of radius $a(1-u^2/c^2)^{1/2}$ is

$$W_1=\frac{e^2}{2a(1-u^2/c^2)^{1/2}}+\frac{e^2u^2}{8ac^2(1-u^2/c^2)^{1/2}}+\ldots$$

$$=\frac{e^2}{2a}+\frac{3}{8}\frac{e^2u^2}{ac^2}+\ldots \tag{11}$$

Taking the average of W and W_1 as an approximation to the energy corresponding to an ellipsoid with axes a and $a(1-u^2/c^2)^{1/2}$ moving in a straight line with uniform velocity, and writing it in a form similar to equation 4

$$W_{\text{average}}=\left(\frac{e^2}{2ac^2}\right)c^2+\left(\frac{e^2}{4ac^2}\right)u^2+\ldots \tag{12}$$

Again if $e^2/2ac^2$ can be identified with a quantity m mass, equation 12 can be written

$$W_{\text{average}}=mc^2+mu^2/2+\ldots \tag{13}$$

Here the first term corresponds to Einstein's equation for the relation of energy to the rest mass and the second term corresponds to the kinetic energy as calculated from Newton's laws of motion.

CHARGED PARTICLE IN ACCELERATED MOTION IN A STRAIGHT LINE

From the preceding expression for the energy of a charged particle in uniform motion in a straight line, the force on the particle when it is accelerated can be obtained. The work done by a force F on a particle is equal to its gain of energy. Hence

$$dW=F\,ds \tag{14}$$

giving

$$F=\frac{dW}{ds}$$

$$=\frac{dW}{dt}\Big/\frac{ds}{dt}$$

$$=\frac{1}{u}\frac{dW}{dt} \tag{15}$$

Applying this to equation 12

$$F=\left(\frac{e^2}{2ac^2}\right)\frac{du}{dt}+\text{terms of higher order in } u^2/c^2 \tag{16}$$

Again, if $e^2/2ac^2$ can be identified with a quantity m mass, equation 16 becomes

$$F=m\frac{du}{dt}+\text{ terms of higher order in } u^2/c^2 \tag{17}$$

and this is simply Newton's Law of Motion that force is equal to mass times acceleration. It will be noted that the above derivation is based on the assumption that u^2/c^2 is small and the acceleration is in the direction of motion.

CHARGED PARTICLE IN UNIFORM VELOCITY IN A CIRCLE

No simple formula is available for the potential due to a charged particle moving with uniform velocity in a circle. Schott gives an expression[4] for the retarded potential which looks simple but as he points out "the calculation of the potentials requires the solution of a transcendental equation which cannot be effected in finite terms." Later in his book he gives expressions involving integrals but they are too complicated to be used here. Therefore it is assumed that the circle in which the charge is moving is large compared with the diameter of the charge and the velocity of the charge is small compared with that of light. Under these conditions, it seems reasonable to assume that the field due to the charge at any point is approximately the same as if it were moving with uniform velocity in a straight line along a tangent to the circle. Thus, the energy in this case is the same expression as in equation 12 now written in cylindrical co-ordinates replacing u by $r\,d\phi/dt$, where r is the radius

of the circle

$$W=\left(\frac{e^2}{2ac^2}\right)c^2+\left(\frac{e^2}{4ac^2}\right)r^2\left(\frac{d\phi}{dt}\right)^2+\ldots \tag{18}$$

From this the centrifugal force F_r on the particle can be derived. From Lagrange's equations of motion[5]

$$\frac{dW}{dr}=F_r \tag{19}$$

giving

$$F_r=\left(\frac{e^2}{2ac^2}\right)r\left(\frac{d\phi}{dt}\right)^2+\ldots$$

$$=\left(\frac{e^2}{2ac^2}\right)\frac{u^2}{r}+\ldots \tag{20}$$

If $e^2/2ac^2$ can be identified with a quantity m then this equation becomes the well known equation for centrifugal force

$$F_r=\frac{mu^2}{r} \tag{21}$$

DISCUSSION

Reviewing these results, it is obvious that if $e^2/2ac^2$ can be identified with the mass of a particle of radius a and charge e, then both Einstein's equation and Newton's equations for these typical motions can be derived from the fields calculated by Maxwell's equation. This agrees with the mass commonly given in textbooks on physics except for a small difference in the constant factor. The value in textbooks for the mass of such a particle* is $2e^2/3ac^2$. It looks as if the reason for the difference must lie in the textbook derivation because it is very difficult to see where any change could be made in the derivation of the energy of a particle at rest given in equation 4, which in turn is based on well known formulae. However, this difference is not vital to the purpose of this paper.

It may be of interest to compare the method followed in this paper with those usually employed in textbooks on dynamics. In the latter a start is usually made with Newton's laws and these are found useful in their present form for many types of problems. As the problems become more complex, the use of Newton's laws in their original form becomes more involved, and it is found that a simpler approach can be developed by starting with energy. This involves building up from Newton's laws systems of equations in which the dependent variable is energy. The equations of Lagrange, Hamilton, the principle of least action, and so forth may be taken as representative of such systems. When these equations are solved, they provide another set of subsidiary equations by which the force, velocity, and so forth, may be derived.

In this article these steps are retraced in the opposite direction by first calculating the energy associated with a particle due to its electromagnetic field. It is then possible to divide this energy into the rest energy mc^2 and the kinetic energy $mv^2/2$. It is also possible to use the energy to find the force acting on the particle and to establish Newton's first and second laws with regard to the motion of a body subjected to a specified force. It is apparent that these calculations are justified only when u^2/c^2 is small.

One point may be raised in retrospect in connection with the equation $W=mc^2$ is that when written in this form the energy appears somehow to be dependent on the velocity of light. But from equation 4 for the rest energy it is evident that m involves the factor $1/c^2$ so that the energy $W=e^2/2a$ is really independent of c. It is easy to understand how this came about historically being gradually evolved from Newton's earlier definition of m as force divided by acceleration. Possibly a better form to use would be to write Einstein's equations in the form $m=W/c^2$ and thus show the dependence of m on c.

* In many modern books the mass is given as $e^2/6\pi ac^2$. The ratio of 4π between this and $2e^2/3ac^2$ is due to the difference in units.

Appendix

The method used in this paper gives an alternative way of considering a problem raised by C. A. Boddie.[6] Boddie arrives at the conclusion that the mass of a charged particle is a constant, independent of the velocity. From this he concludes that the energies of up to 100 million volts which have been ascribed to particles accelerated in betatrons are not correct and his calculations give much lower energies[7] (255,000 volts) to these particles. The difference in these figures is due to the fact that the usual method of calculating the increase of energy uses the formula for kinetic energy

$$W_{KE}=mc^2\left[\frac{1}{(1-u^2/c^2)^{1/2}}-1\right] \tag{22}$$

and Boddie uses

$$W_{KE}=\frac{1}{2}mu^2 \tag{23}$$

where m is the rest mass, u is the velocity of the particle, and c is the velocity of light. When u^4/c^4 is small, these equations give the same result. Mr. Boddie refers to equation 22 as apparent energy and equation 23 as actual energy.

A better understanding of these formulas may be obtained from the equation 12 for the energy of a particle. It should be noted this is a power series in u^2/c^2 and calculating the third term in the series in a manner similar to that used in the text

$$W_{KE}=\left[\frac{e^2}{2a}+\frac{e^2}{4a}\frac{u^2}{c^2}+\frac{5e^2}{16a}\frac{u^4}{c^4}+\ldots\right]-\frac{e^2}{2a} \tag{24}$$

where the rest energy $e^2/2a$ is subtracted from equation 12 in order to obtain the kinetic energy. If as before $e^2/2ac^2$ is identified with a quantity m called mass this becomes

$$W_{KE}=\frac{1}{2}mu^2+\frac{5}{16}\frac{mu^4}{c^2}+\ldots \tag{25}$$

and equation 32 of Boddie's paper is seen to be an approximation to the increase in energy which omits the term in u^4/c^2 plus higher order terms. To get these higher order terms in manageable form, they may be compared with the energy found in the usual way

using equation 22

$$W_{KE}=\frac{1}{2}mu^2+\frac{3}{8}\frac{mu^4}{c^2}+\ldots \qquad (26)$$

This is identical to equation 25 if the coefficient of u^4/c^2 is changed from 5/16 to 6/16. The change seems permissible in view of the number approximations used earlier in this article. It simply means that to get agreement, it would be necessary to use better approximations and this does not seem required by the purpose of this article.

Now rewrite equation 22 in the form

$$W_{KE}=\frac{mc^2}{(1-u^2/c^2)^{1/2}}-mc^2 \qquad (27)$$

where the first term on the right hand side can be regarded as the energy of a charged particle with velocity u and the second term as the energy of the same particle at rest. The physicist has found it convenient to introduce another symbol m_u for the mass of a charged particle with velocity u given by

$$m_u=\frac{m}{(1-u^2/c^2)^{1/2}} \qquad (28)$$

This is the formula questioned by Boddie which introduces the concept of a mass m_u which varies with the velocity.

To calculate the energy of the particle equation 27 can be written in the form

$$W=m_uc^2-mc^2 \qquad (29)$$

Alternatively equation 22 may be used to calculate the energy in which case we only require the rest mass m.

On the other hand, it is perfectly possible to approach the same problem from equation 24 and decide that since the charge e does not vary with velocity and if a is taken to be the radius of the charged particle at rest so that it is a constant, then $m=e^2/2ac^2$ can be considered a constant. In this case the kinetic energy from equation 24 (again changing the coefficient 5/16 to 6/16 as above) becomes

$$W_{KE}=\frac{1}{2}mu^2+\frac{3}{8}m\frac{u^4}{c^2}+\text{ terms of higher order in } u \qquad (30)$$

In this approach this expression must be considered as the complete one for kinetic energy and the value given by Newton of $mu^2/2$ regarded as a first approximation when u^4/c^2 is small. Of course this will require appropriate readjustments in the other equations given by Newton such as that force is equal to mass times acceleration. However, whether equation 27 or equation 30 is used the result is the same.

The physicist has found it convenient to keep Newton's laws in their present simple form, but as a result has been forced to modify the concept of mass, making it depend on velocity as in equation 28, if he wishes to obtain the correct value of energy using this method. However, if one wishes to keep the mass of a particle constant, presumably this could be done by suitably defining it in terms of e, a, and c. In using such a constant mass, however, it is necessary to regard Newton's expression for kinetic energy ($mu^2/2$) as a first approximation and the more extended one given in equation 30 must be used when powers of u^4/c^2 cannot be neglected. If this substitution is made by Boddie in his equation 32, he will arrive at the accepted values for electrons accelerated in betatrons up to 100 million electron volts and for which there is a large background of experimental evidence.

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Simplicity in Transformer Protection

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WHENEVER a fault in a transformer is beginning to form, heat is produced locally, which begins to decompose solid or liquid insulating material and, consequently, to produce inflammable gas. This fact has led to the development of gas-actuated relays for transformer fault protection. Such relays have been in use abroad for many years, and more recently in Canada, but the applications in the United States have been negligible. Small faults develop only slight amounts of gas per time unit. Severe faults, however, quickly develop large amounts of gas and rapidly increase pressure inside the tank. The gas-actuated relays contain two elements: one is a highly sensitive gas-element which operates if gas is developed slowly and which indicates the faults in their incipient stage; the other is a quickly acting pressure element which operates the circuit breakers of the transformer when faults are grave. The experiences

Based on presentations made at the AIEE Great Lakes District meeting, Indianapolis, Ind., October 9, 1946, and at the AIEE winter meeting, New York, N. Y., January 28, 1947.

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The author wishes to express appreciation to F. L. Lawton (M '36) who has provided data concerning experiences over 108 transformer years of service with gas-actuated relays in Canada, to W. A. Wolfe (M '36) who provided data concerning experiences in the United States, and to engineers in Great Britain who provided information on developments and experiences during the war period.

have been very good, and the early indications of faults in their incipient stage have reduced greatly the time for, and cost of, repairs. The sensitivity of the gas-actuated relays is considerably greater than that of any type of electrical transformer protection because of the extremely sensitive gas-element which is an important part of the protection. The gas-actuated relay is a simple and economical protective device which also can be applied to special transformers in which electrical methods are complicated, expensive, of very reduced sensitivity, and, therefore, of limited protective value.

A device that has been little used in the United States for transformer protection is a relay that functions when gas is formed by a fault. The relay depends for operation on the collection of gas over a period of time, or sudden increases in gas pressure.

SUMMARY

1. Simplicity in transformer protection is made possible by the application of gas-actuated relays. These relays can be used with all kinds of oil-insulated transformers, including special transformers such as regulators with on-load tap changers, rectifier transformers, or instrument transformers.

2. In order to get the full benefit of the extremely high sensitivity of gas-actuated relays, only relays which contain two elements are recommended; one giving alarm on incipient faults (gas elements), and the other operating to disconnect the transformer from the system on major faults (pressure element).

3. The sensitivity of gas-actuated relays is considerably higher than it is for any other protective scheme for transformers. Even turn-to-turn faults, for example, are detected before greater damage could develop. However, transient unbalances (magnetizing in-rush currents) do not operate the gas-actuated relay.

4. Differential protection is considered a supplement to gas-actuated relays in large transformers (about 5,000 kva and more) where its addition can be justified economically.

5. The commercially developed and available gas-actuated relays are designed for transformers having a conservator. Experiments have shown that there is no basic obstacle to the development of gas and pressure relays for use with any type of non-conservator transformers, including those with inert gas above the oil level.

6. The application of gas-actuated relays does not require any special transformer construction. The only part to watch is the inside of the cover of the transformer tank. However, any adjustments which might be necessary can be made easily.

GAS-ACTUATED RELAYS

Most of the larger transformers in the United States, in ratings down to not less than a few thousand kilovolt-amperes, are protected by differential relays, and the experience seems to have been satisfactory in most instances. However, the fact that basic improvements, and not only refinements, had to be made and still are being developed shows that this solution has certain inherent limitations.

The ideal protection would be a simple arrangement, quick acting, absolutely selective, and cheap enough to be applicable down to ratings of perhaps a few (instead of a few thousand) kilovolt-amperes, thereby including instrument transformers. It is evident that differential protection cannot provide such a solution, and because there is no other and better electrical scheme available, it seems worth while to investigate other systems which are purely physical in their operation and are unaffected by anything that may happen to the elements of the power transmission system beyond the transformer proper. In particular, the difficulties of false differential relay operation caused by magnetizing in-rush currents are nonexistent in a nonelectrical protective scheme. A solution which comes only near to the ideal protection ultimately may replace all other forms of transformer relay protection, or may put them into the second place of a selective back-up protection.

Gas production in transformers was investigated thoroughly by experiments and tests about 25 years ago by M. Buchholz, an electrical engineer with a utility company in Kassel, Western Germany; and soon thereafter, he filed a comprehensive patent application describing a large variety of protective arrangements. Those arrangements refer in particular to generators with circulating air cooling, and to liquid-insulated transformers, reactors, and capacitors with and without a conservator (oil expansion vessel). As far as is known from the literature, the protective devices for generators have not yet been applied to a great extent; however, a very large number of transformers (with conservator), rated altogether at many millions of kilovolt-amperes, have been equipped during the last 25 years with such gas-actuated relays, or Buchholz relays, as they are called in some foreign countries.[1,2]

Though gas-actuated relays for use on transformers

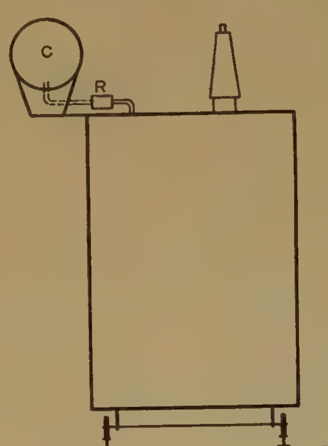


Figure 1. Transformer with gas-actuated relay R installed in pipe line to conservator C

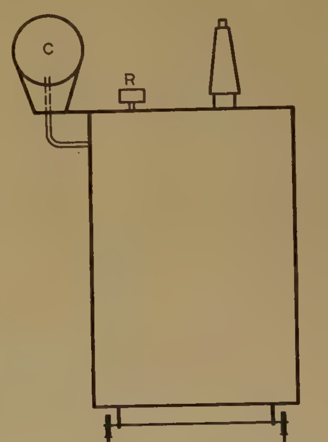
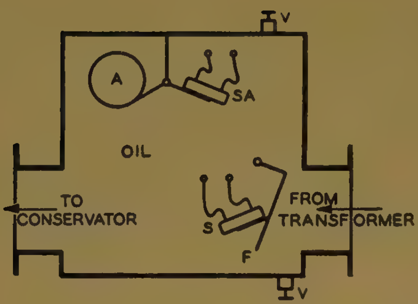


Figure 2. Transformer with gas-actuated relay R placed on top of the cover of the tank



A—Float
F—Flap
SA—Alarm switch
S—Severe fault switch
V—Valve

Figure 3. Pipe-line-type relay in normal "off" position

A—Float
D—Diaphragm
SA—Alarm switch
S—Severe fault switch
V—Valve
L—Oil level in pressure chamber

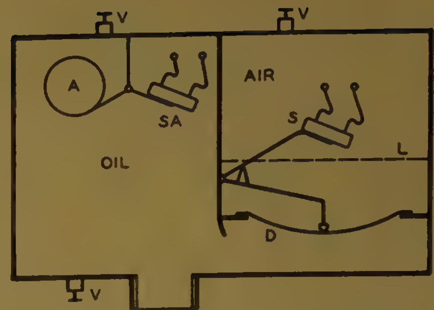


Figure 4. Cover-type relay in normal "off" position

with a conservator were manufactured in the United States some time ago, none is manufactured commercially in the United States at the present time, and the number installed and in operation in this country is limited. These relays are being manufactured and used, however, in Canada and by practically all the large electrical and manufacturing corporations in continental Europe and in Great Britain. Everybody who has personal information about Buchholz relays and the many years of practical experience with them will find it difficult to understand the apparent lack of appreciation in the United States for this simple protective device, which is considered by them to provide the most sensitive and effective protection for liquid-insulated apparatus of the conservator type. The fact that unusual royalty payments were imposed by the inventor seems to be the main reason for the restricted application of gas-actuated relays in this country in the past, but this disadvantage no longer obtains, as the patents terminated.

A similar situation prevailed in Great Britain, where the merits of Buchholz relays had been appreciated for a long time but very few were installed; however, a large increase in the application started some years ago when the period of life of the patent was reaching termination and when British companies took up the manufacturing of the relays. It is of interest to note that in the largest British extra high-voltage system, the Central Electricity Board grid, all transformers with ratings of 1,000 kva up (to 75,000 kva), and all reactors are provided with gas-actuated relays. The transformers are in the voltage range from 3.3 to 132 kv, and all have on-load tap changers with a ± 10 per cent range.[3,4]

The fact that gas-actuated relays have not been described in the available reference literature and hardly are known in the United States to the majority of the profession makes it advisable to describe briefly the types of relays which are in use at the present time. There are two different kinds of relays available, differing primarily in location of insertion and, incidentally, in size.

One is the "first type of relay" (referred to hereafter in this article as pipe-line-type relay), designed originally by Buchholz and considerably improved since then—as a result of field experience by industrial manufacturers—to provide more reliable operation and reduced maintenance. This relay is inserted in the pipe between transformer tank and conservator, as shown in Figure 1. There are various relays available, depending on the diameter of the pipe; the relays are designed for 1-, 2-, or 3-inch pipes. The most usual size for transformers of 1,000 kva up is 2 inches. The 3-inch relays are used for very large transformers, about 40,000 kva up. All the relays built and in use in Europe are of this kind.

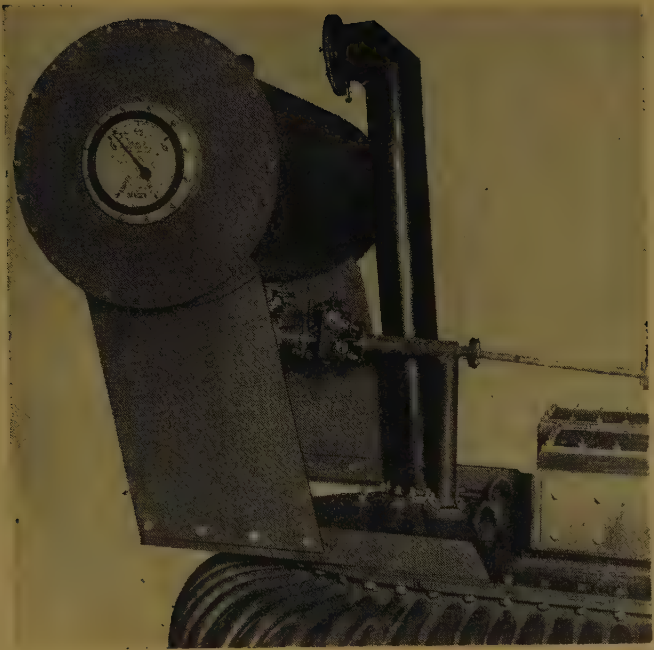
The other type of relay was developed in the United States and is in use here and to some extent in Canada. This type is placed on top of the cover of the transformer through a 3/4-inch pipe thread and, therefore, referred to hereafter in this article as cover-type relay (Figure 2).

DESCRIPTION OF THE RELAYS

The principle of operation is basically the same for both kinds of gas-actuated relays. There are two principal elements present. One element is used to detect minor faults and to operate an alarm if the development of gas is rather slow. The other element operates when a major fault occurs, under the indirect effect of increased pressure inside the transformer tank caused by the quick development of large amounts of gas. The number of pipe-line-type relays in use is considerably larger than the number of cover-type relays, but both have reached a sort of standard design which is completely reliable and free from the troubles of early applications.

The pipe-line-type relay, Figure 3, comprises a cast housing containing a hinged float *A* in the upper part, which acts as a gas collecting chamber. Attached to the float is a mercury switch which closes its contacts *SA* on lowering of the float when a certain quantity of gas has accumulated, and sounds the alarm. The lower part of the housing contains a hinged flap *F* (the pressure element), so located as to be actuated by rapid displacement of oil (or gas) from the transformer tank through the pipe into the conservator.

Attached to the flap is another mercury switch *S* which will close its contacts upon deflection of the flap valve, and consequently will open the circuit breakers and disconnect the transformer. In the 2-inch type the alarm will sound when approximately 160 cubic centimeters of gas have been accumulated, and the flap switch



British Thomson-Houston Company photo

Figure 5. Gas and pressure actuated relay in the pipe line to the conservator

will operate when the oil velocity in the pipe is greater than about three feet per second. Movements of the oil which take place during normal operation (heating of the oil as a result of loading of the transformer, for example) are slow enough so as not to close the switch. A pet cock *V* is fitted to the top of the gas collecting chamber to take the gas out for investigation of inflammability or chemical analysis, and to reset the float. Another pet cock *V* is arranged near the bottom of the casting to permit testing of the relay by inserting air by means of a bicycle or automobile tire pump. Two glass windows are provided, one in the front and one in the back of the relay to make the accumulation of gas (including its color) readily visible. For use with transformers from the smallest size (instrument transformers) up to about 1,000 kva, a single-element relay has been developed. This type of gas-actuated relay, of course, can not discriminate between incipient (gas) and severe (pressure) faults, and the operating conditions of the system determine whether it should be connected for alarm or for tripping.

The cover-type relay, Figure 4, is quite similar in the arrangement of the alarm element that indicates the accumulation of gas in the gas chamber, and the alarm will sound upon accumulation of approximately 25 cubic centimeters of gas. However, the tripping element is somewhat different in its design. In the cast housing, next to the gas chamber is a separate pressure chamber. The upper part of the pressure chamber is filled partly with air, and the lower part is separated from the gas chamber by a flexible diaphragm which is connected to the switch *S* of the tripping element through levers. In case of a severe fault, when large pressure waves are generated, a sudden increase in pressure below the diaphragm will operate the circuit breakers of the transformer through the switch *S*. However, there is provided a high resistance vent connecting both sides of the diaphragm, which equalizes small and slow pressure changes above and below the diaphragm and prevents the operation of the switch under normal operations. The contact in the pressure chamber will close at a pressure of approximately one pound per square inch or somewhat more.

Which type of relay should be installed depends largely on the way the conservator is arranged. The pipe-line-type relay simplifies inspection and routine maintenance because it may be installed farther away from the high voltage transformer bushings than the cover-type relay may be installed. Sometimes, however, the cover-type relay is easier to install—in fact, the only type that can be—if the pipe to the conservator is connected to a side wall of the tank and not to the cover (Figure 2). In order to make certain that all or most of the gas bubbles developed inside the transformer tank find their way into the gas chamber of the gas-actuated relay, it is necessary to arrange the relay on the highest point of the tank. Sometimes changes on the inside of the cover of the transformer may be required, but it will be satisfactory in most instances to make small openings through reinforcing cross walls where they intersect with the cover so that the gas may not be trapped under the cover and prevented from quickly reaching the relay. With a flat top cover, it might be advisable to place the transformer on its foundation with the side having the connection to the relay somewhat tilted up in order to guide gas bubbles to the relay. Other changes should not be necessary in any transformer, because of the danger that air might be trapped inside the transformer at places where oil is needed to give the required dielectric strength. In all properly designed transformers this condition is fulfilled whether or not gas-actuated relays are used. However, it is an advantage of the application of gas-actuated relays that they indicate bleeding of air from the transformer which might be given up by the oil for some time in new installations and after processing of the oil. The gas alarm may indicate bleeding

Figure 6. Gas and pressure actuated relay on top of the transformer cover

Kansas Gas and Electric Company photo

Figure 7. Gas and pressure actuated relay on top of the cover of a 30,000-kva 154-kv transformer

Aluminum Company of Canada, Ltd., photo

for hours or even days, but the gas test and also the successive indication of air at increasing time intervals will show that there is nothing basically wrong inside the tank. Typical examples of practical installations are shown in Figures 5, 6, and 7.

PRACTICAL EXPERIENCES

The experiences with gas-actuated relays have been quite extensive. Such relays apparently provide the most universal and yet simple device for transformer protection by discovering and isolating faults in their early stages, long before troubles can attain disastrous extent. Practice has shown that the transformer should not be opened upon the first indication of inflammable gas, because then it might be difficult to locate a very small fault in its incipient state. It is better to release the gas and to watch successive indications at decreasing time intervals before taking the transformer off the system. Some faults, bad contacts for example, take a very long time, many weeks and even months, to develop an easily visible fault, and experience has shown that the damage and repair are not materially increased because the fault was permitted to develop somewhat further.

Figures 8 and 9 show an incipient joint failure which was detected by the gas alarm of the relay shown in Figure 7. The cover-type relay picked up the fault in ample time to permit repair without inconvenience to system operation. The first alarm came approximately six weeks before Figure 8 was taken. Successive indications of the gas alarm at slowly decreasing time intervals were observed.

In some instances, where both differential relays and gas-actuated relays were installed, it was observed that when the pressure element operated it did so either before, or together with, the differential protection. However, the extremely sensitive alarm contact never was accompanied by the operation of the differential relay. Of course, faults external to the transformer proper cannot be detected by gas-actuated relays. The two systems do not replace, but supplement, each other. A few engineers, though not the majority of those experienced in the application of Buchholz relays, believe that it is as necessary to install differential protection for a transformer equipped with gas-actuated relays as it is to install differential protection for bus bars and bushings to supplement the general system protection. Of course, gas-actuated relays can be applied economically to smaller transformers where differential protection would be much too expensive.

In summarizing the knowledge gained from experience abroad, it appears that electrical and mechanical transformer faults may be divided into two groups. One (*A*) comprises defects which are covered by the alarm element and indicate faults, mostly in their incipient state, that would not be detected by any other kind of protection. Early discovery of these faults will enable quick repair, which is in many instances of greater importance than the reduced repair cost which goes hand in hand with the fact that the fault was detected before it developed into extensive damage to a major apparatus. The other group (*B*) comprises major faults which lead to tripping and the operation of the gas alarm at the same time or perhaps preceding the tripping by a few seconds. Most of these would be indicated by other protective arrangements, though probably not so quickly.

Faults which may be classified under *A* are

Poor contacts resulting from high-resistance oxidized joints.

Insulation failures, usually involving only small portions of the winding such as interturn and intercoil short circuits. Impulse failures.

Phase-to-ground (frame) faults in delta systems or resonant grounded systems.

Core bolt insulation failures, grounded core bolts.

Core faults, burns of the core. Breakdown of core insulation.

Local overheating which generates gas from the insulation of the laminations or from adjacent oil. Puncture of bushings under oil.

Overheating of some part of the winding because of excessive eddy current losses or because of bad contact.

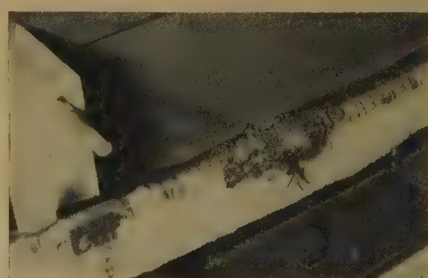
Overheating of devices with short time rating caused by unduly extended operation.

Failing contact on tap-changer, or even open contact with arcing flashover.

Falling oil level because of leakage (punctured tanks during the war), or because of extremely low temperature.

Figure 8. Condition of the connection between the low voltage windings of the transformer shown in Figure 7 when untanked

Note mass of carbon on top, and signs of heating on each side



Ingress of air resulting from defect in the oil circulating system such as leakage in the cooling system or pumping system of transformers with forced oil circulation.

Dissipation of entrapped air, following filtering or processing the oil.

Faults which may be classified under *B* are

Puncture of bushings under oil.

Short circuits and ground faults (in solidly grounded systems).

Short circuits between taps.

Short circuits of a larger number of coils.

In some instances gas-actuated relays can provide protection where the application of differential relays would be either too complicated or even not possible, as for example transformers with on-load tap changers, induction regulators, rectifier transformers, furnace transformers, and instrument transformers.

NONCONSERVATOR TRANSFORMERS

In many foreign countries, most of the transformers of about 500 kva or more are provided with conservators, and for this reason the pipe-line-type relay was developed first and has been used extensively. In the United States, some of the larger transformers are operated without conservator and with inert gas filling the space above the oil level. Obviously, the gas-actuated relays that have been developed commercially and are described in this article cannot be applied to such transformers without modifications. However, solutions for the nonconservator-type transformers were suggested by Buchholz, and he also[5] developed and tested various relays acting on the presence of inflammable gas, which

Figure 9. Connection between the low voltage windings of the transformer shown in Figure 7 after removal of remains of the insulation shown in Figure 8

apply in these cases. Pressure elements for such transformers have been developed in the United States and are available; they are simple in their design, and give promise for success.

It would require many changes and would introduce great complications to use a gas element of the described type for nonconservator transformers, and such a solution appears impractical. However, other gas elements are available which provide a much simpler solution. The problem is simply to indicate the presence of gases in the transformer tank above oil level which are different from the gas filling at sound conditions. For example, in a bridge circuit using electronic measuring devices, the light absorption in the paths of two light beams may be compared; one beam is sent through a test pipe which is sealed and filled with the same gas as is the transformer, the other beam is sent directly through the space above oil level.

Other types of gas elements may be similar to the one described for generator protection,[1] or may be either modifications of the standard equipment used for the recording of chimney smoke density, or modifications of the thermal gas analyzer, which is based on the thermal-conductivity method of gas analysis. Because of the lack of demand for, and lack of interest in, such a relay in the past, none is commercially in production now. A relay of this kind also will have to operate either an alarm or the circuit breakers, depending on the severity of the fault. Neither a pressure element alone, nor a gas alarm alone, can provide a complete solution.

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High Frequency Heating in the Radio Spectrum

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The development of electronic heating, both induction and dielectric, has made possible many applications which were impossible with conventional methods of heating. However, the radiation which may be produced by electronic heating equipment can interfere seriously with radio communications, thus posing a problem for both industry and the Federal Communications Commission. The findings of the AIEE subcommittee on electronic heating, which was formed to study the situation, are reported in this article.

DURING the past ten years a new electronic industry has grown to major proportions. This industry, commonly called the electronic heating industry, involves the use of radio-frequency power for the heating of electrically conducting and nonconducting materials. The growth in the use of equipment of this type has resulted in the development of many forms and varieties of high-power radio-frequency oscillators or generators. These generators are built in powers which may run from less than 100 watts to 300 kw or more. The use of thousands of such radio-frequency generators naturally produces problems of radio interference.

INDUCTION HEATING

Electronic heating may be divided into two classes or distinct phases, induction heating and dielectric heating. Induction heating is the heating of an electrically conducting body by subjecting it to a periodically varying magnetic field. The conducting object is placed in a work coil carrying radio-frequency current, and the object thus becomes the short-circuited secondary winding of a transformer and, as a result, currents circulate in or near the surface of the object. These currents cause conventional I^2R heating. In addition, in magnetic materials there will be some hysteresis heating which usually is neglected. Induction heating therefore is used principally for the heating of metals and a few electrically conducting nonmetals, such as carbon.

Heating of this type has many advantages. For example, its location and depth may be controlled with great exactness and the speed of heating can be 100 times faster than by conventional flame or furnace heating methods. The method is also clean and little or no scale is formed on the object being heated, thus giving greater die life in forging operations, and also permitting grinding before hardening. Today, induction heating commonly is used in industry for hardening, annealing, brazing, melting, and forging with results that often are impossible to obtain by any other method of heating.

Figure 1 shows a typical induction heating setup for hardening the edge on conventional ice skate blades. The skate, which is positioned on a conveyer setup, is carried through a work coil in which radio-frequency current at a frequency of 375 kc per second is circulated. The generator producing this current is not shown in the illustration. In passing through the coil, the edge of the skate is heated progressively to hardening temperature and then, upon emerging from the coil, passes into an oil jet quench zone. By this process, the edge of the skate is hardened to a depth of 3/16 inch, while the balance of the skate remains in an unhardened ductile state. Conventional methods previously used hardened the blades throughout, with subsequent brittleness which left the blades subject to breakage in use.

As stated, induction heating is produced fundamentally by a varying magnetic field. This magnetic field is produced by the work coil which surrounds or is close to the object being heated. The work coil may have several hundred, or perhaps several thousand, amperes of radio-frequency current flowing through it. The voltage developed across the coil terminals may be a few hundred volts or several thousand volts, depending upon the coil impedance and current. As the coil is generally in an exposed position, it is a potential source of radiation which may cause radio interference. In properly designed equipment, any other radiating source will be shielded within a metal cabinet. Induction heating generally is done at frequencies under 500,000 cycles per second, which is below the radiobroadcast band and thus will not interfere with radio communication unless harmonics are radiated by the equipment.

DIELECTRIC HEATING

Dielectric heating is the heating of electrically nonconducting bodies, or the heating of materials that are nominally insulators, by subjecting them to a periodically

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varying electrostatic field. The electrostatic field stresses the material being heated in exactly the same manner in which the dielectric of a capacitor is stressed. The voltage stress causes dielectric hysteresis losses which appear in the form of heat and some I^2R resistance heating which results from leakage currents that may flow through the work. This method produces heat uniformly throughout the material, a definite advantage over conventional oven practice which requires the flow of heat into the work or material by thermal conduction.

The materials which may be subjected to dielectric heating cover a very broad field. They may be in a variety of forms; either solid, liquid, or powder; and may range in type from wood to water. Dielectric heating is used industrially for such applications as preheating plastics prior to moulding, curing the glue in wood gluing operations, drying various materials, and baking foundry cores.

Figure 2 shows a piece of equipment which dielectrically glues edge moulding on a switchboard panel. The panel is shown in place in the lower center. The moulding which is to be glued in place is seen around the edge of the irregularly shaped panel. This moulding is pressed in place by the air-actuated pressure clamps mounted around the periphery of the panel. Directly beneath the edge of the panel is a copper electrode, shaped the same as the upper electrode shown on the raised cover of the equipment. In operation, the panel is placed over the lower electrode, as shown. The clamps are closed for holding the edge moulding in place, the upper electrode, which is mounted on a hinged cover, is pulled down in place over the moulding, and the power is turned on. This applies a radio-frequency voltage at 20 megacycles per second between the two electrodes across the glue line for heating the thermosetting glue, and causes it to harden. The operation takes place in approximately two minutes. (The generator which produces the voltage is not shown.) The upper electrode and cover then are lifted, the clamps released, and the panel removed, ready for further processing. To set the glue by conventional means, the panel would have to be held in clamps for many hours.

Radio-frequency radiation from dielectric heating equipment may be serious as the frequencies usually used range from 1,000,000 to 200,000,000 cycles per second or more, and because the fundamental heating setup usually consists of electrodes on which a high radio-frequency voltage, which may be as high as 15 kv, is applied. The fact that high voltages are used at megacycle frequencies is conducive to appreciable radiation. Therefore, particular emphasis must be placed upon the shielding of dielectric heating equipment as compared with the requirements for induction heating equipment.

Figure 1. Conveyer, coil, and quench table for hardening running edge of ice skate blades

DIELECTRIC HEATING FOR MEDICAL PURPOSES

One form of dielectric heating is used extensively throughout the world. This is the use of diathermy for medical purposes. Generally, such equipment has a comparatively low power rating of from 200 to 600 watts, and is used exclusively by the medical profession for the production of heat within a patient's body. Diathermy units are of two types, one of which uses conventional capacitor-type electrodes which are placed upon or adjacent to the patient, while the other utilizes a flexible coil which may be wound around the patient, or around that part of the body to be heated. In both instances, the frequencies used are usually greater than ten megacycles per second. As extreme flexibility of application is required, it is impractical to shield the electrodes or inductors for diathermy equipment, and thus there may be appreciable radio-frequency radiation. In addition, diathermy equipment very often is used in congested residential sections and so may cause interference with local radio reception.

Electronic heating equipment is fundamentally a radio-frequency oscillator of the vacuum tube or spark gap type, the power of which is utilized to produce heat within various types of materials rather than being fed intentionally to a radiating system, such as an antenna. However, if the equipment is not constructed properly and shielded, radiation of radio-frequency energy may take place from those component parts which are at high radio-frequency potentials and have appreciable length, thus approaching the requirements of a radio transmitting antenna.

Radio-frequency power may be radiated from any object of finite length carrying an alternating current. However, radiation reduces with frequency and, for all

practical purposes, can be considered negligible below 10 kc per second. The radiation of energy is half in a magnetic field, called the induction field, and half in a dielectric field, both of which may be measured by use of an instrument called a field strength meter. This instrument, which is much like a radio receiver, will measure the radiation in terms of microvolts per meter. Such instruments are portable and may be moved from spot to spot to make measurements which give a field strength pattern around a given source. Field strength meters for high frequencies usually use a rod antenna, and at the lower frequencies use an electrostatically shielded loop antenna.

The output frequency of induction and dielectric heating equipment varies from 10,000 cycles per second to 1,000 megacycles per second or more, thus covering the entire radio-frequency spectrum.

PREVENTION OF RADIO INTERFERENCE

Radio-frequency radiation is absolutely essential to the functioning of the radio communications industry. In the electronic heating industry such is not the case. The industry's fundamental purpose is to supply heat energy, and radiation of a radio-frequency nature is not required beyond the confines of the actual equipment. Therefore, if the electronic heating equipment produces a radiation which may interfere seriously with the communication services, it is justifiable that the communication services should seek regulation of this nonessential radiation. However, such regulation should not be more strict than is necessary to prevent actual interference with the communication services, otherwise the electronic heating industry becomes excessively burdened and restrained in development.

The following is a report of the activities that have taken place in the past several years on the regulation of the electronic heating industry insofar as radio interference is concerned.

In November 1942, J. L. Fly, then chairman of the Federal Communications Commission, suggested that the radio industry form a technical advisory group to work with the Government and make recommendations and engineering suggestions for the betterment of the industry. This group actually was established in 1943 as the Radio Technical Planning Board. It set down as its objective the following:

"The objective of the RTPB shall be to formulate sound engineering principles and to organize technical facts which will assist in the development, in accordance with the public interest, of the radio industry and radio services of the nation, and to advise Government, industry, and the people, of its determinations. Such activities shall be restricted to engineering considerations."

The RTPB consisted of 13 technical panels, each of which was to deal with a specific phase of the general radio industry, such as frequency allocation, television, and aeronautical radio. Panel 12 was set up for industrial, scientific, and medical equipment. Its objective was to study the characteristics of this equipment with particular reference to potential radio interference.

On December 29, 1943, the FCC issued a notice stating that there would be new frequency allocations for the communication services and for other necessary channels. Specific recommendations along these lines therefore would be required from the RTPB, based upon its investigations and findings.

In June 1944, a subcommittee on industrial heating applications was formed as an adjunct to panel 12. It was composed of engineers who had considerable experience and interest in the electronic heating field, either from a manufacturer's or user's standpoint. The subcommittee held its first meeting on February 10, 1944, and, subsequently, met regularly during the spring of 1944, gathering and correlating a considerable amount of data on radio interference. The subcommittee's findings, which

Figure 2. Fixtures for dielectric drying of glued switchboard panels

Panel in place, unclamped

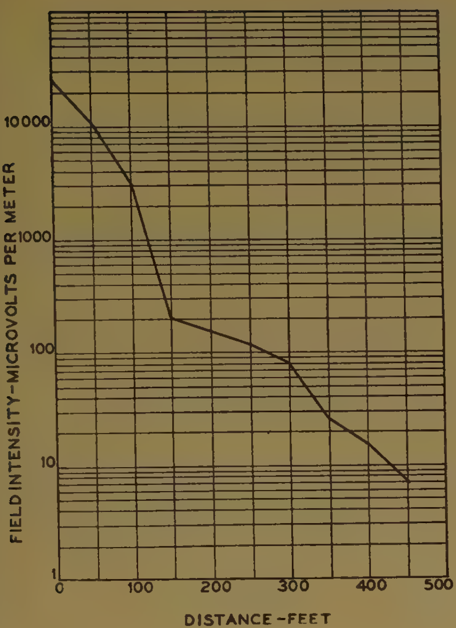

Figure 3 (left). Field intensity versus distance for a 20-kw induction heating generator

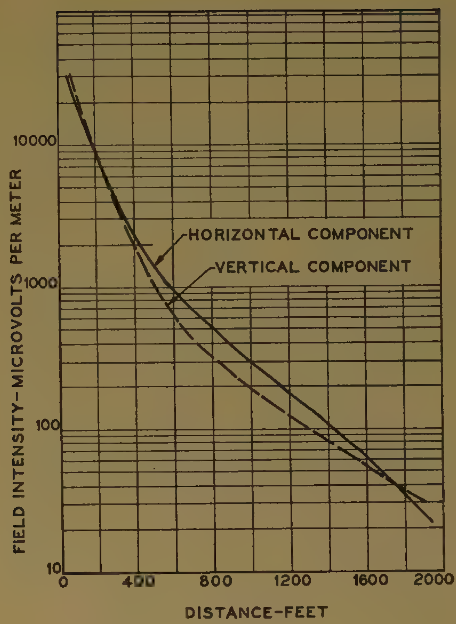

Figure 4 (right). Field intensity versus distance for a 5-kw dielectric heating generator

were submitted in the form of a report to panel 12, covered two methods of eliminating the possibility of radio interference from electronic heating equipment. The first method involved operation of the equipment on an assigned frequency channel with sufficient control to maintain the frequency within a specified band width. In the second method, the equipment would be operated on any frequency, but adequate shielding would be provided to prevent radiation which would interfere with the communication services. As a result, it was recommended that several channels between 225 kc and 491 megacycles be assigned for the use of industrial heating equipment. These channels were to have a band width which ranged from plus or minus 0.1 per cent up to, in one instance, plus or minus 7.5 per cent. For equipment operated on unassigned frequencies, a maximum allowable radiated field strength of 15 to 50 microvolts per meter, to be measured at a distance of one mile depending upon the frequency band involved, was recommended.

As a result of the reports of this subcommittee, panel 12 recommended to the FCC assignment of the frequency bands requested by the industrial heating subcommittee, with an additional five bands in the 1,000- to 20,000-megacycle region for experimental and future work. A wide band at 27.32 megacycles, plus or minus 2 megacycles, was chosen because this section of the radio-frequency spectrum is unsuited for long range communication work and so possibly might be available to the industrial, scientific, and medical fields.

The two methods of preventing radio interference naturally present some problems to the industry. If electronic heating equipment is operated on an assigned frequency with close band width frequency tolerances, considerable increase in cost of the equipment is involved. Normally, a radio transmitter feeds a fixed antenna, and thus has a nonvarying load. However, in the case of the electronic heating generator, the load is highly variable both in amount of power absorbed and in reactance. In both induction and dielectric heating equipment, the load reactance usually determines to some extent the frequency at which the generator will oscillate. As a result, it is most difficult to operate at a fixed frequency unless the equipment is crystal-controlled, or employs the use of a master frequency establishing oscillator which feeds a power amplifier. In either arrangement, an adjustable tuning arrangement is required in order to compensate for changes in the impedance of the work circuit. Because all of this extra equipment introduces extra cost and maintenance difficulties the fixed frequency generator would be used only when no other means of eliminating interference is available.

In the method involving operation outside of the assigned frequency bands, additional cost is incurred by having to provide shielding to reduce the radiation. If the allowable radiation is at a reasonable level, this method is the preferable one, as it generally will cost less, and is much simpler. The shielding must prevent direct radiation from the equipment, and also must stop feedback of radio-frequency power into the power and light system which supplies the generator.

PROPOSED FREQUENCY ALLOCATIONS

On October 27, 1944, the FCC held a series of hearings on the proposed frequency allocations for all of the services. During these hearings, the chairmen of the various committees or panels of the RTPB testified before the commission, giving their specific recommendations on frequency assignments. After the hearing, in January 1945, the FCC issued a lengthy proposal covering the frequency allocations between 25 megacycles and 30,000 megacycles. In this proposal, the industrial and medical

groups were given a tentative frequency band at 13.66 megacycles, 27.32 megacycles, and 40.98 megacycles. Each of these channels was to be maintained within plus or minus 0.05 per cent. No specific proposals were made at that time by the FCC on the allowable radiation from equipment operated outside of the assigned channels. The radiation within each assigned channel was to be unlimited.

On February 28, 1945, the FCC held a hearing on the proposed allocations. At this hearing, testimony was presented by members of the RTPB committee on industrial heating applications, as well as by members of the medical profession, and manufacturers of diathermy equipment.

After the hearings, final frequency allocations were issued by the FCC on May 17, 1945. These allocations for industrial, medical, and scientific equipment were as follows:

13.66 megacycles—plus or minus 0.05 per cent
27.32 megacycles—plus or minus 0.5 per cent
40.98 megacycles—plus or minus 0.05 per cent

No specific allowable radiation levels for equipment operating on unassigned frequencies were given at that time. Furthermore, no allocations were made below 13.66 megacycles, and as induction heating equipment generally operates well below this frequency, it is apparent that no provisions were made for this type of equipment.

During this same period, Canada had formed the Canadian Radio Technical Planning Board, the activities of which closely paralleled those of the RTPB in the United States. The Canadian panel *F*, which was equivalent to the United States panel 12, made requests for frequency allocations from the Department of Transport similar to those requested in the United States. The final assignment was the same as in the United States, except that all the channels were of a narrow band width.

The Canadian Standards Association now is setting up standards of good engineering practice for tolerable limits of interference from such equipment. It is proposed in Canada that radiation would be permitted on other than assigned frequency channels if the radiation is below the general radio noise level or below the level of 10 microvolts per meter at 1,000 feet from the source of the radiation.

On December 5, 1945, the AIEE formed a subcommittee of the electronics group on electronic heating, which consisted of manufacturers, users, and a representative of the FCC.

The primary function of this group was to gather data on radio interference, and determine recommendations on the allowable radiation from equipment operated outside of the assigned frequency bands. During 1946 many tests were made and a considerable amount of data were accumulated on radio interference and the effect of shielding. Many of these tests were performed in conjunction with the FCC laboratory group, which co-operated by sending field crews to make measurements on equipment made available by manufacturers and users. Tests were made on both induction and dielectric heating equipment of a variety of capacities and at various locations in the United States. The field strength pattern around various installations was determined and, at the same time, long distance observations were made by the listening posts of the FCC.

TEST RESULTS

The subcommittee assembled and correlated all of this information and, in discussion with the FCC's committee member, obtained a tentative agreement on an allowable radiation level of ten microvolts per meter at one mile. Typical test results are shown in Figures 3, 4, and 5, which illustrate field intensity with various types of equipment under various conditions. Test results show that dielectric heating equipment was the principal offender as far as radio interference is concerned. Induction heating equipment in general presented no problem, if properly constructed.

Figure 3 indicates field intensity versus distance for a 20-kw induction heating generator operating at 406 kc per second, with a water-cooled steel load heated by a 2-turn work coil. No attempt was made to shield the coil leads, coil, or the load. Only the normal steel cabinet was used for shielding on the equipment itself. It can be seen from the curve that the attenuation is quite rapid, and it is apparent that this type of setup should cause no radio interference within the prescribed limits.

Figure 4 shows field intensity versus distance on a 5-kw dielectric heating generator operating at 30 megacycles per second. The load was a variable power factor water-cooled capacitor arrangement. The diagram shows both the vertical and horizontal polarized components of the radiation with a low power factor load. The equipment and load were shielded in a conventional cabinet, the load itself being covered by a perforated aluminum housing. This also would cause no interference within the prescribed limits.

Figure 5 illustrates a polar curve of field intensity versus direction for a $1^1/_2$-kw dielectric heating unit operating at 26.6 megacycles per second with no work between the electrodes, thus utilizing an air capacitor load. The measurements were made on the horizontal polarized radiation at one-fourth mile distance. Measurements were made with and without a shield. It can be seen from the curve that the shield produces a considerable reduction in field intensity.

OPERATING RULES FOR INDUSTRIAL HEATING

When all the data and other information desired by the FCC and the committee had been assembled, the Commission issued a public notice on September 20, 1946, listing proposed rules relating to the operation of indus-

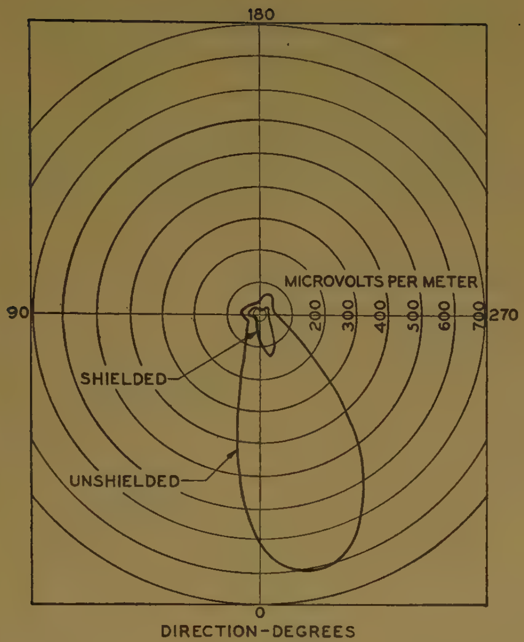

Figure 5. Polar curve of field intensity versus direction for a 1 1/2-kw dielectric heating unit

trial heating as well as diathermy equipment. In this notice, the FCC proposed that industrial heating equipment should be operated on any of the three previously assigned frequency channels with unlimited radiation. However, a certification as to the frequency and guaranteed frequency stability of the unit was to be required, and it would be necessary to renew this certification annually.

On equipment which was to be operated outside of the assigned frequency channels, the allowable radiation was not to exceed ten microvolts per meter at a distance of one mile, and the ability of individual equipment to meet this specification was to be certified. This certification was to be renewed each year.

Provisions of a similar nature also were made for diathermy equipment, except that the allowable radiation level was reduced to 15 microvolts per meter at 1,000 feet.

It also was proposed that the foregoing provisions would not be applicable for a period of five years from the effective date of the legislation on radio interference to the operation of equipment manufactured before May 25, 1945.

After the issuance of these proposed rules, the AIEE subcommittee on electronic heating met to determine what steps should be taken to protect the industry from the disadvantageous sections of the proposed ruling. It was gratifying to see that the FCC adopted the suggested allowable radiation level of ten microvolts per meter at one mile. It was believed that the yearly certification which involved several hundred dollars of expense in making measurements on each piece of equipment would be an excessive burden to the industry, particularly because this cost often would exceed the equipment operating cost for a year. In addition, it was believed that the stipulations with regard to existing equipment would be unfair, as no definite rules or specifications would be in existence until the FCC made its final ruling. Thus, equipment manufactured prior to this final ruling could not be expected to anticipate it. Yet, under the proposed ruling, all equipment made since May 25, 1945, would be expected to comply.

It also was deemed desirable that the industry should be allowed a period of time after the enactment of the legislation before it became effective in order to permit redesign of equipment to conform to the rules.

An FCC hearing regarding these proposed rules was held in Washington, D. C., on December 18, 1946. The AIEE subcommittee on electronic heating designated a group of men representing manufacturers and users to submit briefs to the FCC and to attend the hearing in order to testify on the proposed rules. When it was learned that the FCC would appreciate a reduction in proposed testimony because of the very large number of persons expected to testify in addition to those from the AIEE, the subcommittee on electronic heating complied. In addition, because representatives of the National Electrical Manufacturers Association were expected to testify at the hearing, some of whom were also members of the AIEE subcommittee, it was decided further to concentrate the testimony into a combination group of selected NEMA and AIEE members.

At the hearing the group proposed that, instead of a yearly certification on allowable radiation or on operating frequency, an initial certification should be made on type equipment only. This would relieve manufacturers and users of the expense of making measurements on each piece of equipment every year, a really unnecessary burden.

It was proposed that the effective date should be one year from the date of the enactment of the legislation in order to allow manufacturers an adequate period in which to redesign equipment to conform to the rules. It also was proposed that the 5-year stipulation should begin from the date of the enactment of the legislation rather than from May 25, 1945.

Furthermore, it was requested that consideration be given to the assignment of two frequency channels below 13.66 megacycles per second, and also at 500, 1,000, 3,000, 6,000, and 9,000 megacycles per second for further work.

No final decision has been made as yet by the FCC except on the allocation of a frequency channel at 2,450 megacycles per second and in the widening of the channel at 27.32 megacycles per second to a band width of 320 kc per second instead of the original width of 230 kc per second. The widening of the 27.32 megacycles per second channel makes it possible to use reasonably simple equipment for dielectric heating at that frequency, and still be able to maintain the required

frequency stability. An appreciable percentage of the dielectric heating work being done can be performed at this frequency. Exceptions exist, of course, such as in the heating of physically large loads where capacitance is high or where standing waves on electrodes, which result from their length, might give trouble.

A public notice just has been issued by the FCC proposing that additional frequency allocations be made at approximately 6 megacycles per second, and at 915, 5,850, 10,600, and 18,000 megacycles per second. These proposed allocations are in line with those requested by the AIEE subcommittee on electronic heating, and which, without question, indicate that the FCC is making every effort to help the high frequency heating industry find a place in the radio-frequency spectrum.

Adjustable Frequency Control of High-Speed Induction Motors

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MEMBER AIEE

The aviation industry has found numerous applications for high-speed squirrel cage motors to operate over a wide speed range. Elaborate power supply systems have been developed to provide the required range and accuracy of motor speed control. Applications of the systems probably will be found in other industries.

THE squirrel cage induction motor is the simplest type of industrial electric motor available. However, it is essentially a constant speed device, operating at slightly below its synchronous speed which is fixed by the line frequency and the number of poles for which the motor windings were laid out. Once a motor is built, nothing can be done to adjust its speed except by changing the frequency of the a-c power supply.

Wind tunnel tests on powered airplane models necessitate the use of high speed motors which can be controlled to adjust and maintain accurately the propeller speed. Such motors have been built up to 80,000 rpm at 1,330 cycles. The motors are calibrated on dynamometers or torque stands so that the power input and speed can be measured and used to determine the propeller torque required by the actual airplane.

Larger adjustable-frequency motors frequently are used to test full size propellers, either inside or outside a wind tunnel. Adjustable speed testing of compressors and gas turbines is an application of still larger squirrel cage motors. Application in other industries will be found as the system is developed.

BASIC REQUIREMENTS

Because of the availability of large blocks of fixed-frequency power at low cost in industrial plants, adjustable frequency power is obtained from power conversion equipment. Alternators and frequency converters, driven by adjustable speed electric motors, are the two fundamental types of conversion apparatus in use.

The maximum frequency to be attained is governed by the design and rating of the motors used for a particular application. Flexibility is a prime requirement for testing equipments and thus it is necessary to vary frequency over a wide range, generally six to one or more, in a practically infinite number of steps.

During a test it is necessary to maintain the test motor speed accurately so that the testing equipment operates at a stable test point and precision measurements can be taken. Thus, frequency must not only be adjusted at a desired value but it must be regulated accurately at the set value.

Adjustable speed d-c shunt motors with adjustable voltage control are most generally used for driving the frequency conversion machines because such driving systems are ideally suited for wide speed ranges and accurate speed control. Speed is adjusted by adjusting

Essential substance of paper 47-106, "Adjustable Frequency Control of High-Speed Induction Motors," presented at the AIEE North Eastern District meeting, Worcester, Mass., April 23–25, 1947, and scheduled for publication in AIEE *TRANSACTIONS*, volume 66, 1947.

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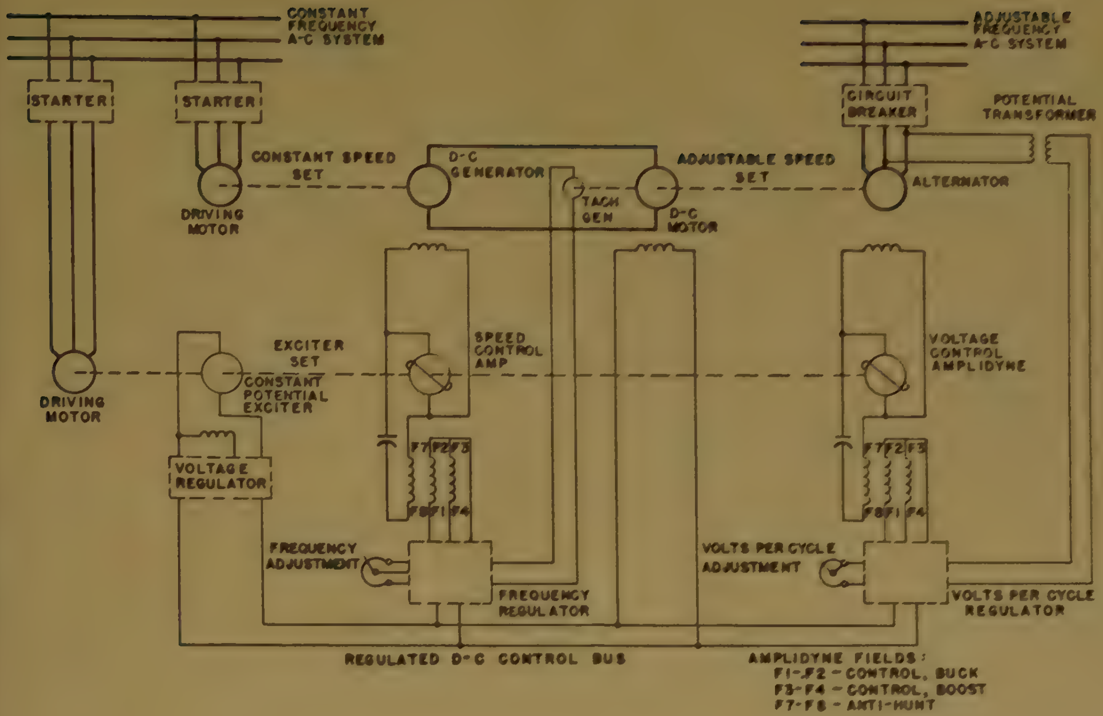


Figure 1. Adjustable frequency control system with an adjustable speed alternator

the voltage applied to the armature of the d-c motor, and within the range of speed control the drive system is able to produce constant torque, in other words, the kilowatt output of the adjustable frequency system changes proportional to frequency. If a wider speed range is desired, an additional four-to-one speed range can be gained by weakening the d-c motor shunt field. However, within the field weakening range the drive system produces constant horsepower which means the kilowatt output of the adjustable frequency system stays constant.

Another problem which has to be given careful consideration is the control of the voltage of the adjustable frequency power system. When a squirrel cage motor is connected to an adjustable frequency power source, the voltage applied to the motor stator terminals should change proportional to frequency in order to maintain constant air gap flux which enables the motor to develop its rated torque over its speed range. It has become customary to rate adjustable frequency motors in terms of "volts per cycle" rather than in terms of volts. Voltage drifts due to natural regulation of the power conversion apparatus should be minimized to enable the squirrel cage motors to develop their full rated torque and to prevent their being overheated. Hence provision should be made not only to control volts per cycle over a certain range but also to maintain volts per cycle close to the set value regardless of the frequency and the load of the system.

SYNCHRONOUS ALTERNATOR SETS

Figure 1 is an elementary diagram of the principal circuits of an adjustable frequency control system utilizing an adjustable speed alternator as a power source. The system is self-contained, requiring no auxiliary power source other than the general purpose a-c power supply in the plant. Use is made of generator voltage control only, but it would be possible to extend the speed control range by motor field weakening. An additional amplidyne then would furnish excitation to the d-c motor field.

Details of the frequency regulator are indicated in Figure 2. Field *F3-F4* of the speed control amplidyne is connected across the regulated d-c control bus in such a sense as to raise the d-c generator voltage and remains at constant strength. The buck field *F1-F2* opposes the boost field, the net difference between the two deter-

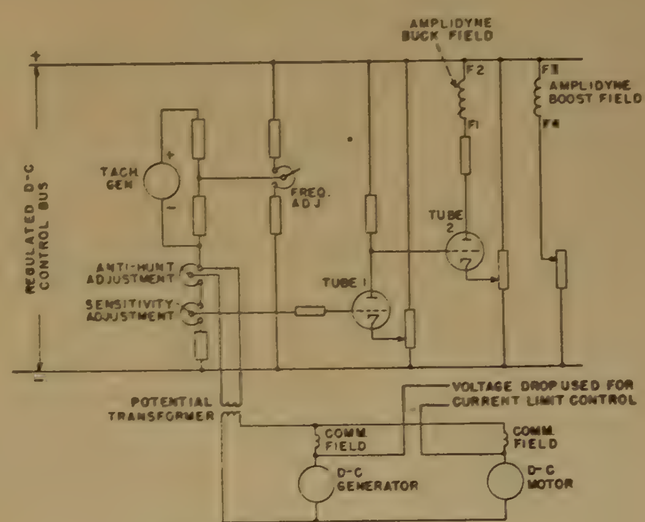


Figure 2. Frequency regulator

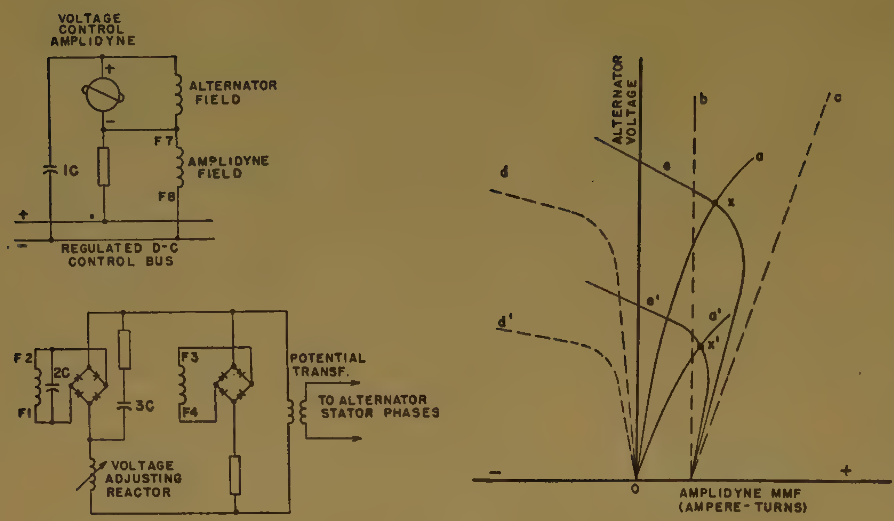


Figure 3. Volts per cycle regulator and performance curves

a—Saturation curve of the alternator
b—Fixed magnetomotive force established by field F7-F8
c—Excitation contributed by field F3-F4
d—Excitation contributed by field F1-F2
e—net magnetomotive force of the amplidyne
a′—Saturation curve of the alternator at half-frequency
d′—Excitation contributed by field F1-F2 at half-frequency
e′—Net magnetomotive force at half-frequency

mining the output voltage of the amplidyne and thus the d-c generator field strength. Two vacuum tubes control field *F1-F2*, and are themselves controlled by the frequency adjusting rheostat and the tachometer generator. An anti-hunt feature is provided by a potential transformer connected to the armature terminals of the d-c generator.

When the generator voltage undergoes a change, a voltage is induced in the potential transformer and is added to the frequency control signal in such a sense as to oppose the change in generator voltage. If current is to be limited to a value which can be commutated safely, the voltage drop across the commutating fields of the d-c generator and motor may be applied to the grid control of tube *2* so as to oppose rapid acceleration or deceleration of the d-c motor.

Figure 3*A* illustrates the operation of the volts per cycle regulator. The voltage of the alternator is rectified and impressed on amplidyne field *F3-F4*, and with opposite polarity on *F1-F2*. The setting of the adjustable reactor in series with *F1-F2* determines the alternator voltage. Capacitors *2C* and *3C* are used for phase shift compensation and to maintain volts per cycle at very low frequencies. Amplidyne field *F7-F8* which is connected to the regulated d-c control bus serves the dual purpose of contributing a fixed amount of flux and acting as the anti-hunt field.

Figure 3*B* illustrates the performance of the regulator. Point *x* is the operating point of the alternator under a given set of conditions. If the frequency is changed, halved for example, the saturation and flux curves change. Point *x′* is the new operating point and is one-

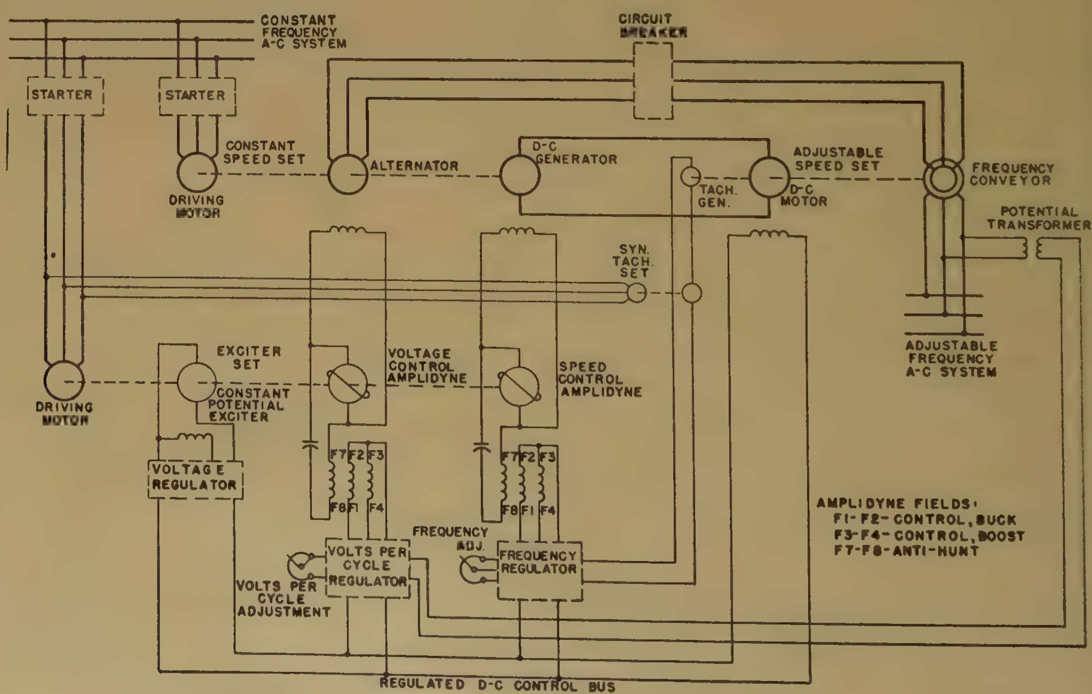
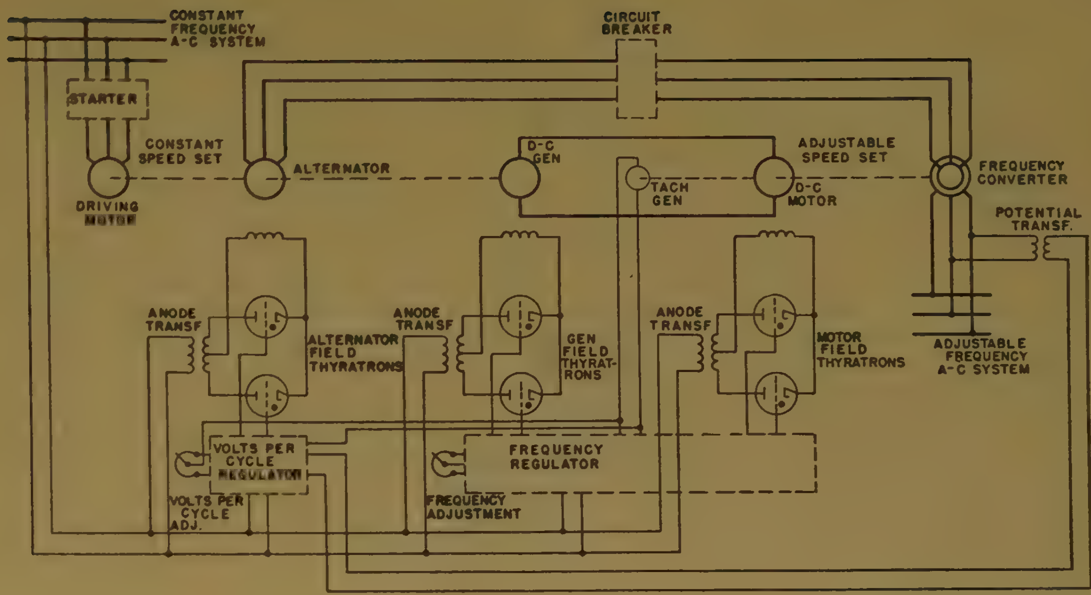


Figure 4. Adjustable frequency control system with an induction frequency converter

Figure 5. Induction frequency converter control system with thyratron exciters



half the value of x. By proper selection of the components of the amplidyne field circuits, it is possible to maintain volts per cycle within narrow limits over a wide range in frequency and load.

INDUCTION FREQUENCY CONVERTERS

An induction frequency converter is built like a wound rotor induction motor. If a fixed frequency is applied to the primary winding and the rotor is at standstill, the frequency appearing at the secondary terminals is equal to the primary frequency. However, if the rotor is driven in the same direction or in the opposite direction as the rotating flux, the secondary frequency is lower or higher than the primary frequency. The output voltage of the converter is determined by the primary voltage and the secondary frequency. If there were no drops and no losses in the converter, the secondary voltage would be equal to the primary voltage multiplied by the ratio of secondary to primary frequency. Actually, this ratio is not accurately maintained. However, by using an adjustable voltage power source for the converter primary, the secondary voltage can be adjusted and regulated.

A practical system of adjustable frequency control by using a frequency converter is illustrated in Figure 4. It resembles the system of Figure 1. An alternator is added to the constant speed m-g set, which supplies primary frequency excitation to the converter. To prevent drifts in primary frequency on account of load changes, the constant speed m-g set should be driven by a synchronous motor. The adjustable speed set consists of the d-c motor and the frequency converter. The circuit breaker for protecting the converter is preferably placed in the line between alternator and converter where standard low-frequency devices can be employed to de-energize the high-frequency secondary circuit. Frequency control is obtained by controlling the field of the d-c generator in a manner similar to that illustrated in Figure 2.

Operation of the system at exactly primary frequency would cause burning of the converter slip rings. For this reason the regulator is adjusted so that it cannot be set at exactly zero d-c motor speed, but that the minimum speed setting will result in the d-c motor turning at a few revolutions per minute.

Volts per cycle is controlled in much the same manner as shown in Figure 3. The voltage control amplidyne excites the field of the alternator, and the voltage signal is obtained from a potential transformer connected across one phase of the frequency converter secondary.

The main advantages of the induction frequency converters are their high overload capacity, stability, and the ease of operation in parallel. The possibility of operation in parallel eliminates great wastes of capacity in stand-by equipment.

ELECTRONIC EXCITERS

The auxiliary exciter sets may be eliminated and thyratron tubes used for exciting the fields of the d-c machines and alternators, as shown in Figure 5. The tubes, connected as biphase half-wave rectifiers, are grid controlled, thereby varying their firing angle and the average d-c current delivered. Electronic regulators containing vacuum tube amplifiers control the grids of the thyratrons.

Frequency regulation is obtained by a comparison of the tachometer generator signal with a reference voltage drop across a portion of the frequency adjustment potentiometer. The regulator also may be used to weaken the motor field if a greater speed range is desired than can be obtained by raising the d-c generator voltage.

Volts per cycle is controlled by comparing the signal from the frequency converter with the tachometer generator voltage which is proportional to frequency.

Progress in Television

GEORGE R. TOWN
MEMBER AIEE

The background of the "status quo" in standardization of this youngest offspring of communications is reviewed, and the contributions of the NTSC, the RTPB, and wartime developments evaluated. In outlining the immediate future of television, due consideration is given to commercial problems, and predictions are hazarded about the course color television will follow in view of the recent FCC decision.

THE PROBLEMS of present-day television broadcasting may be understood best after considering some of the factors involved in introducing commercial television in the period just before the war. Although experimental television broadcasting had existed for at least ten years previously, regularly scheduled television broadcasting commenced in the spring of 1939. It was inaugurated on April 30 of that year when the National Broadcasting Company broadcast by television the opening ceremonies of the New York Worlds Fair. For the succeeding ten months television broadcasting stations and manufacturers of television receivers worked intensively to develop an expanding public television service, and on February 29, 1940, the Federal Communications Commission announced that limited commercial sponsorship of television programs would be permitted after September 1, 1940. This was the "go-ahead" signal which the television industry had been awaiting, as commercial sponsorship meant expanding program service which would lead to a larger volume of sales of television receivers which, in turn, would stimulate the sponsors to provide still better programs. Some portions of the television industry, however, commenced to move forward at a pace which was more rapid than that intended by the Commission. At that time the Commission had not decided finally on certain aspects of the technical standards on which television broadcasting is based, and in the opinion of the Commission, too rapid commercialization of television inevitably would result in freezing these standards at their then current level. This the Commission wished to avoid, and therefore, on March 23, 1940, the Commission rescinded its order of February 29 relating to commercial sponsorship.

On May 28, 1940, the FCC stated that it was ready to approve full commercialization of television as soon as the engineering opinion of the industry was united on the acceptance of a comprehensive set of television standards. In an effort to provide the means for accomplishing this standardization, the Radio Manufacturers Association formed the National Television System Committee. This committee, together with its nine panels, each of which considered certain aspects of television standardization, was composed of engineering representatives of the various companies in the television industry, and during the succeeding eight months, this group undertook a comprehensive study of all technical aspects of television.

In order to appreciate the problems which faced the NTSC, some of the technical factors involved in television operation must be reviewed briefly. Furthermore, these same factors have an important effect on problems of present-day television. General principles of the operation of modern electronic television have been outlined many times[1,2] and need be referred to only briefly.

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SCANNING TECHNIQUES

In any modern television system, the principle of scanning is of fundamental importance. By scanning is meant the method whereby the spatial distribution of light intensities in a picture is converted into a time variation of an electrical signal, together with a reconversion of this signal into a picture image. In this process, a picture focused on a photosensitive surface essentially is divided into a large number of elementary areas. Through the mechanism of the photoelectric effect, each of these areas assumes an electrical potential dependent upon the brightness of that picture element. These potentials are converted into an electrical signal by means of a beam of electrons which acts as a contacting device and which is swept over the picture area in a predetermined pattern.

In a television transmitter, this scanning process takes place in a television camera tube in which the first important element is a plate upon which the image to be

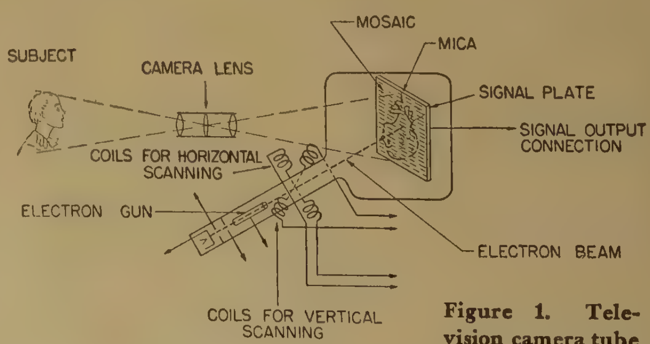


Figure 1. Television camera tube

transmitted is focused optically. The surface of the plate consists of a multitude of photoelectric cells. The beam of electrons is formed in an electron gun structure and is swept across the surface of the plate by means of electrostatic deflection plates, or magnetic deflection coils (Figure 1). This description applies particularly to the iconoscope type of camera tube, but all types of camera tubes employ variations of the same fundamental principles. At the receiver, the scanning process again is employed to reproduce the picture (Figure 2). The beam of a cathode-ray tube is deflected in such a manner that it sweeps over the fluorescent screen in synchronism with the electron beam in the camera tube. The picture signal is applied to a control grid in the tube and varies the current in the electron beam, so that the intensity of the fluorescent light produced at any spot on the screen is proportional to the brightness of the corresponding picture element on the plate of the camera tube. Because of the persistence of vision, the entire picture on the screen is seen, rather than a succession of bright and dark spots, if the picture repetition rate is sufficiently high.

From the foregoing brief description of the scanning process, it is obvious that a number of matters require standardization in order that television receivers can be built to receive pictures from more than one television transmitter. One of the most important of these is the determination of the pattern to be followed by the scanning beam. For a variety of reasons, a rectangular scanning pattern is used universally today. In following such a pattern the electron beam moves from left to right across the picture area in a straight line and at a uniform rate. Upon reaching the right-hand edge of the picture, it is returned quickly to the left-hand edge from which it moves again in a straight line to the right-hand side. During this horizontal scanning, a vertical scanning also occurs whereby the beam moves at a much slower rate from the top of the picture area to the bottom and then returns quickly to the top. The result is that the beam covers the picture area in a series of parallel nearly horizontal lines.

PICTURE TRANSMISSION

Once the general form of the scanning pattern is determined, it is necessary to specify the number of lines per picture and the number of times per second that the picture is transmitted. The picture repetition rate is determined by the tolerable amount of flicker at normal receiver picture brightness. Flicker is minimized by so-called interlaced scanning whereby during one vertical scan, lines 1, 3, 5, and so on are traversed, and during the next vertical scan, lines 2, 4, 6, and so on are traversed. A consideration of these factors leads to the conclusion that approximately 30 complete pictures or frames per second, or approximately 60 vertical scans or fields per second, are sufficient to minimize flicker to a degree consistent with current picture brightnesses. The exact value, namely, 30 frames, 60 fields per second,

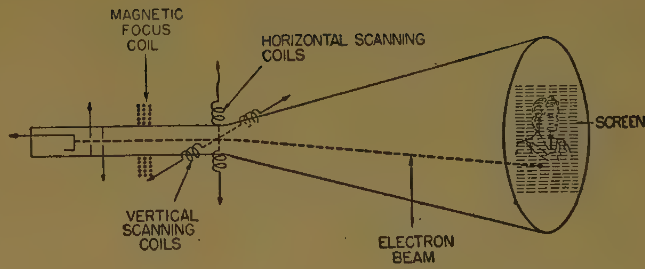


Figure 2 (above). Television picture tube

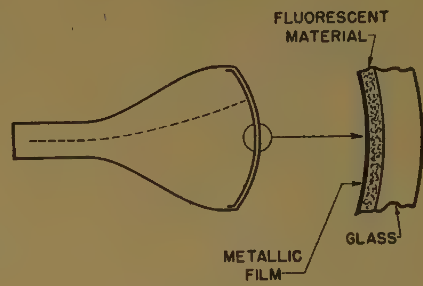


Figure 3. Coated screen picture tube

was chosen because such operation maintains the picture scanning in synchronism with normal power supplies, thus minimizing picture disturbances due to stray pickup from the magnetic field of power transformers and other interference synchronous with the power supply.

After the picture repetition rate is specified, a determination of the number of lines per picture is made on the basis of certain engineering compromises. The greater the number of lines, the greater will be the vertical resolution of the television picture. In order to maintain satisfactory picture quality, the resolution in the horizontal direction should be approximately the same as that in the vertical direction, or the elementary picture area should be approximately square. Therefore, the number of elementary areas into which a picture is divided by the scanning process depends upon the square of the number of lines. Thus, for maximum picture detail, the number of lines should increase without a limit. However, the maximum fundamental frequency component of the resulting picture signal is also directly proportional to the number of elementary areas scanned per second. Thus, the frequency band required to transmit the picture signal is proportional to the square of the number of scanning lines per picture. The picture signal eventually is used to modulate a radio-frequency transmitter. As the amount of space in the frequency spectrum available for television transmission is limited, and as a number of stations in any one area must be accommodated within this portion of the spectrum, it is necessary to limit the maximum picture detail to reduce the band width of the radiated picture signal. In picking a suitable number of lines, it is necessary also to consider the subjective effect on the eye of the average observer. As with many other physiological phenomena, the subjective effects approximately follow a logarithmic law.[3] Thus, it has been determined experimentally that at relatively high degrees of picture sharpness, a much larger increase in the number of lines is required

to produce an observable increase in picture sharpness than is necessary at lower degrees of picture sharpness.

A consideration of all these factors led the NTSC to recommend 525 lines per picture. This choice gives approximately equal horizontal and vertical resolution and results in a maximum picture signal fundamental frequency of approximately four megacycles. This can be accommodated within a total television channel width of six megacycles through the use of partial single-side-band transmission. To produce a substantial increase in the sharpness of the picture would require such a large increase in band width that an adequate number of stations could not be accommodated in the available portion of the spectrum.

SYNCHRONIZING RECEPTION WITH TRANSMISSION

Another question raised by the description of the scanning process is the method whereby the scanning at the receiver can be kept in step with the scanning at the transmitter. This is accomplished by transmitting horizontal synchronizing signals during the brief interval required for the scanning beam at the transmitter to return from the right- to the left-hand side of the picture, and by transmitting a different type of vertical synchronizing signals during the longer period required for the beam to return from the bottom to the top of the picture. These signals are of a polarity corresponding to black in the picture, but have an amplitude greater than the maximum black which is transmitted. Therefore, they do not interfere with the resulting picture, as they completely cut off the electron beam of the picture tube at the receiver.

At the receiver, the synchronizing signals are skimmed off the top of the picture signal, the vertical synchronizing signal is separated from the horizontal, and these signals are used to trigger the sweep oscillators which generate the voltages or currents which deflect the electron beam in the picture tube.

A large number of forms of synchronizing signals had been evolved, and it was necessary for the NTSC to select the type of synchronizing signal which, in its opinion, gave the best all-around performance with respect to reliability of synchronism in the presence of interference and with respect to its ability to be used in a wide variety of receivers at minimum receiver cost.

Still another problem requiring standardization is the polarization of the transmitted signal. Beyond the camera tube and its associated scanning circuits at the transmitter, the picture signal is used to modulate a radio transmitter which, in turn, feeds a transmitting antenna. Conversely, the front end of a television receiver is essentially a radio receiver designed especially to pass the required high-frequency signals to the picture tube. The transmission through space from the transmitting antenna to the receiving antenna is accomplished through the medium of electromagnetic waves.

Because of the high picture signal frequencies involved, carrier frequencies between 40 and 220 megacycles are used in present systems. Therefore, the antenna structures are small, and the antenna can be oriented either horizontally or vertically. From the viewpoint of standardization, all transmitters should transmit with the same antenna polarization in order to be received well on a single receiving antenna. Among the factors that must be considered are propagation through space, variation in field strength at the receiver caused by multipath reflections and fading, signal-to-noise ratio, and simplicity of transmitting and receiving antennas. It was the conclusion of NTSC that horizontal polarization is preferable.

Figure 4. Projection receiver employing Schmidt lens system

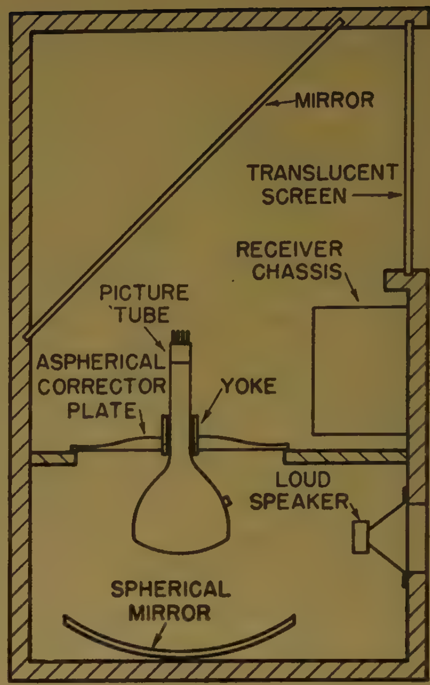
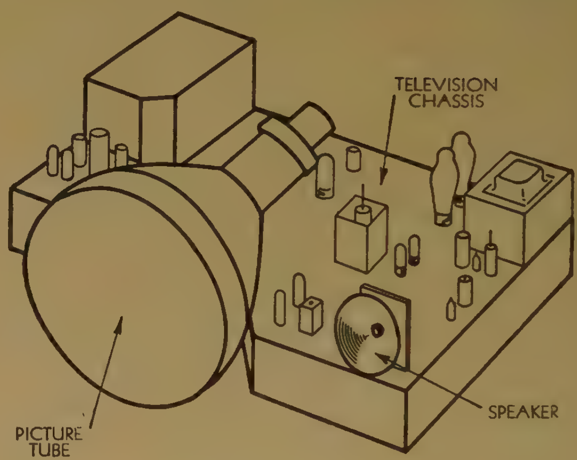


Figure 5 (below). Arrangement of chassis, picture tube, and other components in a typical table model television receiver



SOUND ACCOMPANIMENT

A final controversial matter requiring standardization is the method by which the sound which accompanies the picture should be transmitted. Present practice is to employ a separate radio transmitter for the sound

and to incorporate a sound channel in the television receiver which is tuned automatically at the same time as the picture channel. The sound transmitter may employ either amplitude or frequency modulation, with a number of variables being required in the complete specification in either type of modulation. It was the conclusion of the NTSC that frequency modulation should be employed and that the standards for such transmission should be the same as for frequency modulation radiobroadcasting.

These items are among the most important and most controversial which required standardization by the NTSC. Other questions related to the exact location of the sound and picture carrier frequencies within a 6-megacycle television channel; the ratio of picture width to picture height; a specification of the relationship between polarity of modulated signal and increase in light intensity; a specification of the levels corresponding to black and white; and the relative power of picture and sound transmitters.

It cannot be overemphasized that successful wide-scale television broadcasting depends upon the specification of a satisfactory set of standards which will insure that all transmitters perform certain functions in identical manners, for only thus is it possible to build receivers which will be useful in receiving more than one station.

1941 STANDARDS

As a result of the great amount of study given to the problem by the NTSC, a set of standards embodying the conclusions outlined in the preceding paragraphs was agreed to by an overwhelming majority of the television industry. This set of standards was submitted to the FCC and was adopted by the Commission substantially as recommended. The FCC officially adopted the NTSC standards in May 1941 and announced that commercial television broadcasting would be permitted beginning July 1, 1941.

The television industry proceeded to move forward rapidly on the basis of the FCC order, and during the summer of 1941 manufacturers designed television receivers for production early in 1942. Applications for a large number of television transmitter licenses were filed with the FCC, and existing stations expanded their broadcasting activities. There was every indication that 1942 would have seen the beginning of widespread television service in the United States, if United States entrance into World War II had not intervened.

WARTIME TELEVISION ACTIVITIES

Although television broadcasting was continued on a reduced basis throughout the war, practically all of the resources of the television industry were converted to wartime electronic research, development, design, production, operation, and maintenance. The importance of the background of the television industry in the development of radar and other wartime electronic techniques scarcely can be overemphasized. Television was the first extensive application of pulsed radio techniques, and therefore, all of the background of engineering knowledge of television circuits and equipment was directly applicable to radar, aircraft identification, and loran systems. In addition to employing television signal circuits, many of these wartime applications of electronics employed television picture tubes and associated sweep and synchronizing systems, or techniques evolved from television practices.

Although not of major importance in the winning of the war, television, itself, did have some military applications. The most important of these was the use of television transmitters in remotely controlled reconnaissance airplanes and guided missiles. The extensive use of television in the atomic bomb tests at Bikini has received nation-wide publicity. As in other military applications, the television camera was substituted for the human eye at points where observation by military personnel was exceedingly unsafe.

It was inevitable that the application of television techniques to wartime purposes should result in improvements which would be applicable to peacetime television. Many of the rapid improvements in circuits, techniques, and components brought about by wartime developments in radar are directly applicable to television. Another important factor is the reduction in cost of certain types of electronic components as a result of the mass production required by wartime applications. These improvements can result only in less expensive receivers.

Early in the war it was recognized that wartime developments might have a profound influence not only on television but on all phases of radio work. Consequently, in accordance with the suggestion of the chairman of the FCC, an organization known as the Radio Technical Planning Board was organized late in 1943. The object of this organization was to study the problems of the radio industry and the advances made during

Table I. Authorized Television Broadcast Stations (March 15, 1947)

City	Stations Total	Stations Operating	City	Stations Total	Stations Operating
Albuquerque, N. Mex.	1		Minneapolis, Minn.	1	
Ames, Iowa	1		New Orleans, La.	1	
Baltimore, Md.	3		New York, N. Y.	3	3
Boston, Mass.	1		Philadelphia, Pa.	3	1
Buffalo, N. Y.	1		Pittsburgh, Pa.	1	
Chicago, Ill.	4	1	Portland, Oreg.	1	
Cincinnati, Ohio	1		Providence, R. I.	1	
Cleveland, Ohio	2		Richmond, Va.	1	
Columbus, Ohio	1		Riverside, Calif.	1	
Dallas, Tex.	1		Salt Lake City, Utah	1	
Detroit, Mich.	2		San Francisco, Calif.	3	
Fort Worth, Tex.	1		Schenectady, N. Y.	1	1
Hollywood, Calif.	1		Seattle, Wash.	1	
Indianapolis, Ind.	1		St. Louis, Mo.	1	1
Johnstown, Pa.	1		Stockton, Calif.	1	
Los Angeles, Calif.	5	1	St. Paul, Minn.	1	
Louisville, Ky.	1		Toledo, Ohio	1	
Miami, Fla.	1		Waltham, Mass.	1	
Milwaukee, Wis.	1		Washington, D. C.	4	1

the war, and "to formulate plans for the technical future of the radio industry and service, including frequency allocations and systems standardization in accordance with the public interest and the technical facts, and to advise government, industry, and the public of its recommendations." This organization was sponsored by non-profit groups having important interests in radio, including AIEE.

Panel 6 of the RTPB was charged with the responsibility of reviewing the television standards and frequency allocations in the light of wartime developments. This panel was organized along the lines of the NTSC. After careful study, the NTSC standards were reaffirmed in all their essentials. This is considered by many to be of considerable significance in indicating the fundamental soundness of the NTSC standards, because it was shown that commercially practical and perfectly acceptable television broadcasting could proceed on the basis of these standards, even in view of the large amount of wartime electronic development. The only significant respect in which the RTPB recommendations differed from the NTSC standards was a slight change in the specification of certain parameters of the frequency modulation sound channel which were necessitated by anticipated operation at higher carrier frequencies than were considered practical before the war. In the course of its deliberations, panel 6 of the RTPB reviewed a number of unconventional television systems as well as the status of color television and other types of high-definition television which eventually may be used at ultrahigh frequencies. The recommendation that television broadcasting should proceed on the basis of the slightly modified NTSC standards was unopposed in panel 6. Besides the standards for commercial television broadcasting, panel 6 of the RTPB also considered standards of good engineering practice for television transmitters and standards for television relay stations. The recommendations of the RTPB with respect to television standards were adopted by the FCC and form the basis for postwar television operation.

WARTIME TECHNICAL IMPROVEMENTS

Probably the most significant wartime development directly applicable to television was the development of the Image Orthicon. Prior to the war the sensitivity of television camera tubes, such as the iconoscope, image dissector, and orthicon was so low that a high level of illumination of the scene to be transmitted was absolutely necessary. Good pictures could be produced in well-lighted studios or on bright days outdoors. The low sensitivity of the pickup device imposed a serious limitation to the application of television to military problems. Therefore, an extensive research and development program was undertaken by the Radio Corporation of America to improve the sensitivity of television cameras by several orders of magnitude.

The program led to the development of the Image Orthicon which is so sensitive that recognizable pictures can be produced using a single candle placed a few feet from the subject. Really high-quality pictures can be produced at illumination levels of a few foot-candles, whereas several hundred foot-candles were required with prewar pickup devices. Development of the Image Orthicon has made it practical to produce good television pictures under any daylight condition outdoors and under reasonable indoor illumination. The importance of this contribution in widening the scope of available television subject matter can not be overestimated. Early models of the Image Orthicon were incapable of giving as high picture resolution as some of the prewar camera tubes. Recent improvements, however, have resulted in the production of an Image Orthicon which gives entirely satisfactory resolution, as well as high sensitivity.

Substantial improvements also have been made in the picture tubes on which television pictures are reproduced. Before the war it was necessary to view television in dimly lighted rooms because of the low level of brightness which could be produced on the face of the picture tube. High ambient illumination was especially troublesome in viewing television pictures, because with low maximum picture brightness the contrast between bright and dark portions of the picture was destroyed rapidly as the ambient level was increased. Wartime developments resulted in increasing maximum picture brightness from a prewar level of approximately 10 foot-lamberts (when using a 12-inch picture tube) to 75 or 100 foot-lamberts. This result was accomplished primarily by backing the fluorescent screen with a thin metallic coating (Figure 3). This coating is sufficiently thin to permit the penetration of electrons, but it still acts as a reflecting mirror on the back of the screen. Loss of light from the back of the screen thus is prevented, together with the spurious scattering of light by the interior surface of the picture tube bulb. The conducting metallic coating also permits the use of high electron accelerating voltages and minimizes the production of a dark ion spot at the center of the picture. The net result is not only an increase in maximum picture brightness but also an even greater increase in contrast between different portions of the picture and, therefore, an apparent increase in picture resolution. Recently, great improvements also have been made in the fluorescent material used in cathode-ray tube screens.

By combining all known improvements, the Allen B.

Table II. Pending Television Broadcast Applications (March 15, 1947)

City	Number	City	Number
Bloomington, Ind.	1	Detroit, Mich.	2
Boston, Mass.	1	Los Angeles, Calif.	1
Cincinnati, Ohio	1	Newark, N. J.	1
Cleveland, Ohio	1	New York, N. Y.	4
Dallas, Tex.	1	Philadelphia, Pa.	1
Dayton, Ohio	1	San Francisco, Calif.	1

Figure 6. Television console with radio and record player

DuMont Laboratories, Inc., has produced pictures having highlight brightness of several hundred foot-lamberts using picture tubes 15 and 20 inches in diameter. Such pictures are entirely suitable for viewing in broad daylight and make it practical to view television in the home under any lighting conditions.

SCHMIDT LENS SYSTEM

The problem of picture size is related directly to picture brightness. Though a television picture of any desired size can be produced by optical enlargement of a small picture, the geometry of the situation indicates that picture brightness is decreased as the square of the linear magnification. The enlargement is limited further by the inherent loss of light in the lens system. It is impractical, therefore, to produce large pictures by optical enlargement, unless the optical system has a large effective aperture and the original picture is very bright. The developments mentioned previously have led to the production of bright pictures. High aperture optical systems of the Schmidt type were developed before the war. These systems consisted of a spherical mirror plus an aspherical corrector plate to compensate for the aberrations inherent in the mirror (Figure 4). Prewar Schmidt lens systems were very expensive and were believed to be impractical for home television receivers, although applicable to theater television receivers. However, the systems were used in considerable quantity in radar equipment during the war, and techniques were developed for the relatively economical manufacture of the various elements of the system. It is, therefore, economically feasible to use these high efficiency lens systems for producing pictures of adequate brightness, approximately 20 inches by 15 inches, by enlarging the image on a 5-inch picture tube operating at 20,000 to 30,000 volts second anode potential and using a metal-backed fluorescent screen.

Another approach to the problem is to avoid the difficulties inherent in an optical system by using a picture tube of large diameter. Picture tubes 20 inches in diameter are being produced and are being used in commercial television receivers. Thus the television receiver designer now has two entirely practical methods of approaching the problem of building a receiver capable of producing pictures large enough for use in any home.

Another wartime advance in picture tubes was the development of mass production techniques. Cathode-ray tubes were used in tremendous quantities in radar and allied equipment. All of the mass production techniques have not been directly applicable to the production of large television picture tubes, but nevertheless the application of some techniques has resulted in a substantial decrease in the cost of picture tubes. It is inevitable that the price will be reduced further as other techniques are applied.

TELEVISION NETWORKS

Transmitting television programs from one city to another in order to link a number of television transmitters into a network long has been recognized as a problem which must be solved before television can be a significant feature of national life. The coaxial cable which the American Telephone and Telegraph Company laid between New York, N. Y., and Philadelphia, Pa., before the war, was used to transmit television programs between these two cities. Extension of coaxial cables to all large cities of the United States is one method of building a television network. The possibility of using ultrahigh-frequency television relay transmitters also was proposed prior to the war. This second method has become much more practical as a result of the intensive development of the ultrahigh-frequency and microwave regions of the spectrum for a wide variety of military uses. Completion of the experimental all-relay network under construction between New York and Boston, Mass., will offer an opportunity to compare radio relay links with coaxial cable on an experimental basis.

A large number of miscellaneous advances in circuits, techniques, and components have resulted from the intense wartime activity in the field of electronics. Some of these advances include the development of relatively high-power transmitting tubes for operation in the very high-frequency and ultrahigh-frequency regions, the development of antennas having a high degree of vertical directivity to increase the effective power radiated by the transmitter, the development of improved receiving tubes, the development of new techniques in the design of wide-band high-frequency amplifiers, and the further development of high-frequency high-voltage power sup-

plies.[4] The mass production of miniature tubes has had an important effect on the design of television receivers, as their use, together with the use of other miniature components, has diminished considerably the amount of space required by television receiver chassis.

As a result of the wartime technical improvements and their application to a television system based on a sound set of technical standards, present-day television has reached a state of technical excellence which permits it to provide pictures of unquestionable entertainment value.

PRESENT STATUS OF TELEVISION

It had been expected that television would expand rapidly after the war. Much progress has been made, but it is apparent that the growth of the industry has not been as rapid as had been predicted. Reconversion problems have been numerous in the electronic industry. Shortages of materials, components, and skilled labor have retarded the production of television receivers as they have retarded the production of radiobroadcast receivers. Moreover, the necessity of setting up production and inspection lines for building complicated television equipment has led many manufacturers to concentrate on the production of other items which can be manufactured more easily and for which there is an equal public demand. As an index of the present status of the television industry, less than 10,000 television receivers were built during 1946. The present trend, however, is indicated by the fact that more than 5,000 television receivers were built in January 1947. As of March 12, 1947, the FCC had authorized 58 television broadcast stations in 38 cities. Of these, 9 were in regular operation in Chicago, Ill.; Los Angeles, Calif.; New York; Philadelphia; Schenectady, N. Y.; St. Louis, Mo.; and Washington, D. C.; as indicated in Table I. In addition, applications for 16 station authorizations in 12 cities were pending before the Commission. These are listed in Table II.

COAXIAL INSTALLATIONS

Television networks have been mentioned previously. At the present time one network exists and is used to connect stations in Washington, Philadelphia, New York, and Schenectady. Programs of special interest are carried over this network. A coaxial cable is used to connect Washington, Philadelphia, and New York, while the Schenectady station uses a special receiver on a mountain top to pick up the New York transmissions which then are relayed to the Schenectady transmitter. A radio link also is used on occasion between New York and Philadelphia. At the present time the American Telephone and Telegraph Company has one section of coaxial cable either installed or under construction connecting New York; Philadelphia; Washington; Richmond, Va.; and Charlotte, N. C.; and another section connecting Jacksonville, Fla.; Atlanta, Ga.; Jackson, Miss.; Shreveport, La.; Dallas, Tex.; and El Paso, Tex. Other short sections also are installed, giving a total of more than 2,700 miles of coaxial cable. It is estimated that an additional 3,000 miles will be installed in 1947 and within a very few years Boston; Miami, Fla.; Los Angeles; and Seattle, Wash.; all will be connected by one coaxial trunk with another main trunk connecting New York; Philadelphia; Pittsburgh, Pa.; Chicago; St. Louis; Kansas City, Mo.; and Denver, Colo.; and another running from Milwaukee, Wis., to New Orleans.

PROGRAMMING

In the cities in which commercial television broadcasting exists, a wide variety of programs is broadcast. New York has the advantage of having three commercial television stations in regular operation, and, consequently, the owner of a television receiver has the opportunity of choosing the type of program which he wishes to receive. Sporting events have proved to be highly satisfactory program material, and boxing, wrestling, football, baseball, and basketball are broadcast regularly throughout their respective seasons. During the 1946 football season, New York television viewers frequently had their choice of seeing any one of three collegiate football games on a Saturday afternoon. The Louis–Conn heavyweight championship fight was covered in a masterful fashion by the National Broadcasting Company and served to demonstrate to thousands of persons the type of television sports programming which is available today. Dramatic presentations also have proved to be very popular.

All television broadcasting stations are engaged in a comprehensive program of developing proper techniques for presenting dramatic sketches, variety shows, and news broadcasts. The techniques involved are allied to, but nevertheless are distinctly different from, those employed in radio, in motion pictures, and on the stage. Current events also provide an excellent source of television program material and will be of special interest as television networks are extended. The opening sessions of Congress and of the United Nations General Assembly are examples of the type of program which is at the same time educational and entertaining. Motion picture films afford an excellent source of television program material from the technical point of view. The appeal of this type of subject matter, however, depends upon the availability of up-to-date feature films. Motion pictures can be made especially for use in television broadcasting, and such pictures can be used to advantage as well as standard motion pictures.

The ever-present question of paying for television programs is a problem which must be solved before television broadcasting can be commercially successful. The cost of a good television program is high. A number of advertisers have recognized the potential value of television, and sponsors, advertising agencies, television

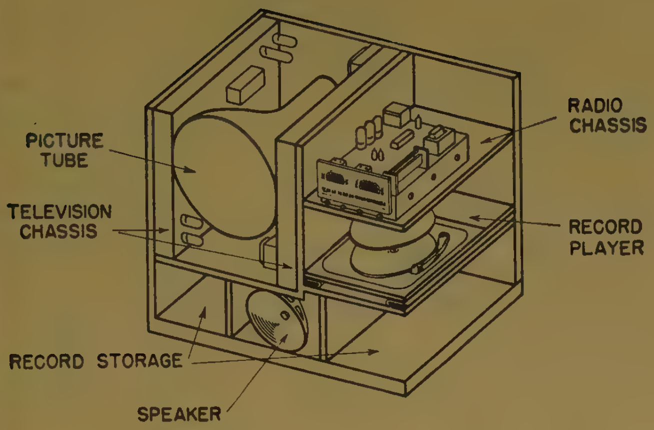


Figure 7. Arrangement of chassis, picture tube, and other components in a typical medium priced console model television receiver

production specialists, and television broadcasting stations are working together to develop the right formula for successful sponsorship of television programs. The problem of presenting the advertisers' products in a forceful and at the same time attractive manner is receiving a large amount of attention.

RECEIVER MANUFACTURE

Numerous manufacturers have offered television receivers for sale, and additional manufacturers have exhibited preproduction models of their television receivers.[5] A great variety of types has been designed, but, in general, television receivers fall into three main classifications. The first of these is the table model, which usually contains equipment to permit reception of television pictures and the accompanying sound, but no additional radio equipment (Figure 5). These receivers, in general, use picture tubes either 7 inches in diameter or 10 inches in diameter, giving pictures approximately 6 by $4^1/_2$ inches, and $8^3/_4$ by $6^1/_2$ inches, respectively. In designing table models, one objective is to reduce the size as much as possible, but television receivers are inherently larger than radiobroadcast receivers because of the space required to accommodate the picture tube. The second class of television receiver is the medium-priced console (Figures 6 and 7). This type of receiver commonly employs a picture tube between 10 inches and 15 inches in diameter. Usually, but not necessarily, facilities are included to permit the reception of amplitude-modulation and frequency-modulation radiobroadcast transmissions, and frequently an automatic record changing phonograph also is included. The third type of television receiver is the expensive, de luxe, large-picture receiver (Figure 8). The usual picture size is between 18 by $13^1/_2$ inches, and 24 by 18 inches. Either an optical projection system or a large diameter, directly viewed picture tube may be used. A complete amplitude modulation–frequency modulation radio receiver and an automatic record changing phonograph almost always are included in receivers of this class. The cabinets required to house large-picture receivers are quite bulky. Typical sizes are 48 inches high by 36 inches wide by 24 inches deep, and 38 inches high by 64 inches wide by 24 inches deep. All television receivers, regardless of classification, are designed to receive at least 6 or 8 of the 13 assigned television channels. Some receivers contain provision for receiving all 13 channels, but most manufacturers do not consider this necessary, because all channels will not be assigned in any one particular locality. The price of television receivers is high in comparison with optimistic estimates made during the war. Table models range in price between $200 and $400. Console receivers producing pictures of moderate size sell for between $400 and $900. The price of de luxe receivers is between $1,200 and $2,800. In nearly every case an additional amount of from $25 to $75 is charged for installation and maintenance up to one year.

The most difficult problem in installation is that of the antenna. The antenna must be designed to permit reception on all channels (44 to 216 megacycles) and must be located and oriented to minimize the reception of ghost signals reflected from large buildings and hillsides. The problem is complicated greatly by the fact that television activity centers in the large cities where many people live in large apartment houses. In most locations an outside antenna is required. If many antennas are placed on the roof, the situation may become chaotic with one antenna shielding another antenna from incoming signals and with each antenna acting as a radiator to broadcast interference to other antennas in the vicinity. Obviously an array of television antennas does not add to the appearance of the roof. Some apartment house owners have prohibited the erection of television antennas and have stated that tenants will not be permitted to use television receivers requiring outside antennas until master antenna systems are available. Such systems have been developed experimentally and consist of one or more master antennas connected through amplifiers to a coaxial cable distribution system which feeds signals to a large number of outlets. Such equipment is expensive, and the necessity for it may hamper the growth of television in some localities.

The extensive sale of television receivers depends to a considerable degree upon the price of the receivers and upon the availability of good programs. Programs are expensive to produce, and sponsors are not attracted to any medium of advertising unless the circulation is large. The circulation will be large when receivers are available in quantity at a reasonable price. Thus a vicious circle exists, which is being broken, not suddenly but gradually, by competition among manufacturers of receivers and among the program departments of competing television stations. As a matter of fact, at the present time there is a very large demand for television receivers in many of the areas where television broad-

casting exists, and the immediate growth of television is limited chiefly by the ability of the manufacturers to produce receivers. An authority on television has stated that there is nothing wrong with television that 100,000 receivers would not remedy.

Looking toward the future, many people are optimistic regarding television broadcasting. This optimism is based on the technical excellence of present-day television performance; on the indisputable appeal of certain television programs, not only to the public, but also to advertisers; on the present large demand for television receivers; and on the rosy prospects for network operation. Others, however, recall that television has been "just around the corner" for many years and point to the high cost of television transmitters, of television operation, of television programming, and of television receivers as evidence that the corner will not be turned soon. Another factor influencing the pessimists is the fear of obsolescence. The great improvements that have taken place in television in the last ten years often are quoted as reasons for postponing widespread television operation for an indefinite period of time until television shall be better than it is today. In particular, the fear of obsolescence due to the supposed imminence of color television often is given as a reason for not pushing forward at full speed on black-and-white television as it exists today.

COLOR TELEVISION

There is no doubt that color pictures are more attractive than black-and-white pictures, all other factors being equal. Practically every company concerned with television development has spent, and is continuing to spend, time and money in an effort to develop color television to the point where it can be considered to be commercial. Radical differences of opinion have existed among various parts of the industry as to the state of development of color television at any given time, the time required to complete the development, the proper compromises in system performance which must be made to permit the introduction of color, and the comparative costs of color and monochrome television receivers.

Color television is not a new thing. The Columbia Broadcasting System has been very active in color television, but it is not the only worker in the field. The Radio Corporation of America, the General Electric Company, Allen B. DuMont Laboratories, and Zenith Radio Corporation in this country, and Baird in England are among those who also have done a large amount of color television work. The status of color television was studied carefully by the NTSC and the RTPB. Both of these groups decided that the time required to complete the development of color television was such as to prohibit its introduction in the immediate future. The television panel of the RTPB unanimously recommended that no standards for color television be assigned for immediate commercialization.

In October 1946 the Columbia Broadcasting System petitioned the FCC for immediate commercialization of color television, using standards which it had developed and with the proposed transmitters operating between 480 and 920 megacycles. Shortly thereafter, the Radio Corporation of America made the first public demonstration of a different type of color television, which was claimed to have a number of advantages over the Columbia Broadcasting System color system, but which admittedly would not be ready for commercialization for approximately four years.

PRESENT COLOR SYSTEMS

Any practical television system proposed to date necessitates the transmission and reception of three television pictures. In the transmitter the image of the scene is projected onto the screen of the camera tube after passing through red, green, and blue filters. Thus, three television signals are produced corresponding to the red, green, and blue components in the transmitted scene. At the receiver the three signals are used to control the pictures on the fluorescent screen of the picture tube, or tubes, and each of the three pictures is viewed through a red, green, or blue filter. The resulting pictures are synthesized by the eye of the observer, who then sees the picture in natural color.

The system proposed by the Columbia Broadcasting System is termed a sequential system, whereas the Radio Corporation of America system is described as simultaneous. In the sequential system the full channel width is utilized to transmit in succession the pictures corresponding to the red, green, and blue components. This is accomplished by placing a rotating color filter disk in the path of the light focused on the camera tube screen at the transmitter, so that the camera tube receives successively the light values carried by the red, green, and blue components of the light (Figure 9). At the receiver, the picture is produced on a normal black-and-white screen, which is viewed through a rotating color filter disk synchronized with the filter disk at the transmitter, so that, for example, the observer sees a red

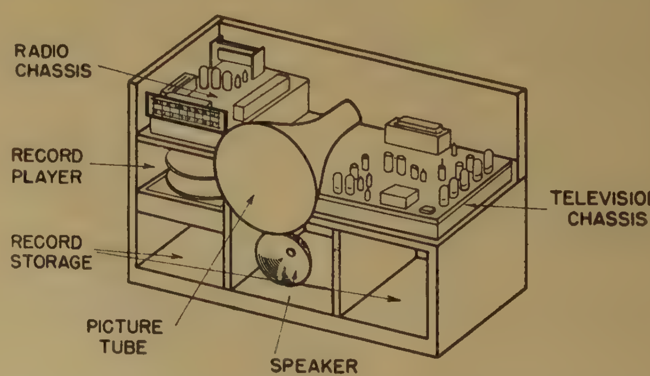


Figure 8. Arrangement of chassis, large directly viewed picture tube, and other components in a typical de luxe television receiver

picture when the red component of the picture is being transmitted. Synthesis of the complete picture is accomplished through the persistence of vision.

In the simultaneous system all three color components of the picture are transmitted simultaneously. In effect, the system consists of three independent but synchronized television transmitters and receivers, one of which handles the red component of the signal, one the green, and the other the blue (Figure 10). This is accomplished at the transmitter by an optical light-splitting system. At the receiver the three colored pictures are produced on three separate picture tubes, or on three separate areas of one picture tube. The three images then are focused optically on a viewing screen.

Either system of color television presents certain problems as compared with monochrome television. Some of these problems are the result of the limitations of present-day equipment, but some are of a very fundamental nature. Both systems require a large increase in frequency band width to produce pictures having the same resolution as monochrome pictures. This is a fundamental limitation, because with either system more picture information must be transmitted in a given time, and, therefore, a greater band width is required unless the picture is compromised by accepting lower resolution or a lower picture repetition rate.

Certain technical factors indicate that compromises can be made which will permit the transmission of color pictures by the simultaneous system with a somewhat lower band width than that required by the sequential system. The determination of the correct compromises to be made must be based on a thorough understanding of all factors involved and especially on a knowledge of the subjective effects of various changes in system performance. As a specific example, it is necessary to know the relationship between color picture repetition frequency and flicker. Particularly in view of the introduction of picture tubes of high brightness, it is necessary to have a sufficiently high repetition rate to avoid annoying flicker. An effect similar to flicker is the stroboscopic effect which results when the observer blinks his eyes or moves his head slightly while viewing pictures produced by the sequential system. This effect, which is very annoying to some observers, does not exist in the simultaneous system.

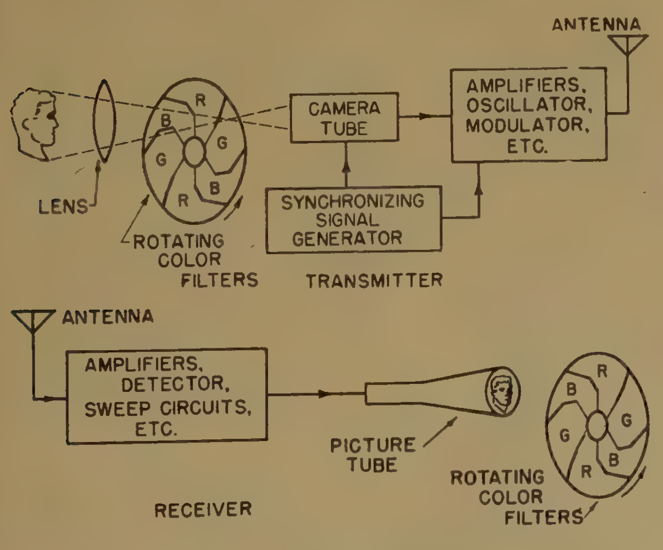


Figure 9. Sequential color television system—simplified diagram

Because of the wider frequency band required to transmit color pictures, the carrier frequency employed must be greater than that required by monochrome transmission. At the present time the amount of radio-frequency power which can be generated in transmitting tubes operating in the 500 to 1,000 megacycle region and arranged for continuous broad-band operation, as required in television, is quite limited. At the higher frequencies, however, directive antennas can be built in smaller space, and the greater directivity of the transmitting antenna partially compensates for the lower power output. This is an equipment limitation and one which may be resolved in time.

Another more fundamental difficulty exists with operation at the higher frequencies. This difficulty is caused by the sharper shadows cast by obstacles in the transmission path and by the greater absorption of the transmitted waves. Field experience at these frequencies is strictly limited, and the results obtained to date are quite contradictory, but there seems to be no question that transmission difficulties will exist to a greater extent than at the frequencies used for monochrome television.

The cost of any television receiver is high, but the cost of a color receiver is substantially greater than that of a similar black-and-white receiver. Estimates presented to the FCC indicate that a color receiver will cost approximately twice as much as a similar black-and-white receiver.

Television network design is a greater problem with color television than with black and white. Because of their limited transmission band width, present-day coaxial cables are not suited to the transmission of sequential color signals. With a simultaneous system, three separate cables could be used, but their characteristics, and in particular their phase characteristics, would have to be equalized carefully.

The simultaneous system has the inherent advantage of providing a brighter picture, because the light output of three picture tubes is combined at the screen. Conversely, with the sequential system a great loss of light occurs in the insertion of the color filters between the picture tube and the observer. This is not a total loss, however, as the contrast of the picture is protected somewhat from ambient illumination which has to pass through these filters before falling on the face of the picture tube.

The greatest advantage of one system over the other is that the simultaneous system would minimize obso-

lescence of monochrome receivers. Television receivers built to receive present-day black-and-white television signals can not be converted to receive sequential color signals except at great expense. If the color television standards are chosen properly for the simultaneous system, however, a color picture can be received in black and white on present-day monochrome receivers by using a frequency converter ahead of the receiver and by tuning the monochrome receiver to the green channel. This channel contains practically all the picture information required for monochrome reproduction.

With either color system, a large amount of work remains to be done to provide the basic information required for standardization and then to effect the proper compromises among the various specific standards. For example, the final choice between the simultaneous and sequential systems must be made. After the system is chosen, such items as repetition rate, number of picture lines, characteristics of color filters, and location of picture and sound signals within the television channel must be determined. Tentative standards must be chosen and adequately field tested before final choice can be made. All of this work requires time. The corresponding work in the establishment of standards in black-and-white television required four years, and there is no reason to believe that less time will be required for color television.

FCC ATTITUDE ON COLOR

In answer to the Columbia Broadcasting System petition, the FCC held extensive hearings on the status of color television during December 1946 and January and February 1947. The Columbia Broadcasting System petition was opposed actively by most members of the television industry, who believed that sufficient knowledge of the color television problems was not available today and that development work and field testing was

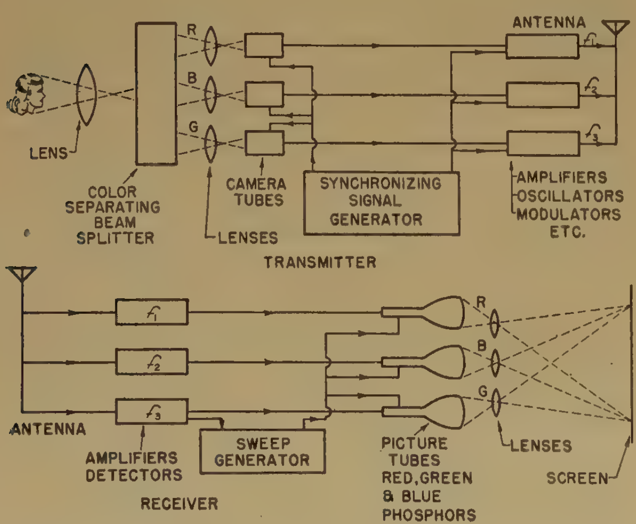


Figure 10. Simultaneous color television system—simplified diagram

not sufficient to permit the establishment of standards.

On March 18, 1947, the Commission announced its decision. The Columbia petition was denied flatly. The Commission stated that in its opinion the evidence did not show that the standards for color television proposed by Columbia represented "the optimum performance which may be expected of a color television system within a reasonable time." This conclusion was based on two grounds:

1. That there had not been "adequate field testing of the system for the commission to be able to proceed with confidence that the system will work adequately in practice."

2. That the Commission believed "there may be other systems of transmitting color which offer the possibility of cheaper receivers and narrower band widths that have not yet been fully explored."

Although the Commission commended the Columbia Broadcasting System for its work in the field of color television, its conclusion was that the system urged for commercialization did not produce a picture of adequate brightness, that problems regarding flicker and color breakup had not been solved satisfactorily, and that the problems of the design of color television receivers and other equipment had not received adequate study. The Commission recognized the absolute necessity of an adequate amount of testing under field operation conditions before standardization could be accomplished. In conclusion, the Commission expressed the hope "that all persons with a true interest in the future of color television will continue their experimentation in this field in the hope that a satisfactory system can be developed and demonstrated at the earliest possible date."

Now that the Columbia Broadcasting System petition has been denied firmly, black-and-white television can proceed to expand rapidly. The public need no longer fear that color television quickly will make their television receivers obsolete. Color television can be introduced when it has reached a satisfactory state of development in such a manner as to permit the continuation of black-and-white television broadcasting throughout the period in which color television is becoming established. The situation will parallel the introduction of frequency-modulation sound broadcasting which does not make obsolete standard amplitude-modulation broadcasting, but rather supplements it, and is capable of giving a greatly superior type of service.

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INSTITUTE ACTIVITIES

Final Arrangements Made for Summer General Meeting in Montreal

All preparations have been completed for the AIEE summer general meeting, which will be held in Montreal, Quebec, Canada, June 9–13. Meeting headquarters will be in the Mount Royal Hotel. A program of broad technical interest, providing ample opportunity for entertainment, trips, and sports, as well as interesting events for women visitors, has been arranged. The technical program, together with a schedule of entertainment, sports, and trips, appears in this issue of *ELECTRICAL ENGINEERING*. For more detailed information about the various events, as well as hotel accommodations and reservations see *ELECTRICAL ENGINEERING*, May 1947, pages 493–5.

Schedule of Entertainment, Sports, and Trips

Monday, June 9

8:30 a.m.	Registration
9:00 a.m.	Women's registration and get-together
12:30 p.m.	Opening luncheon Welcome to the city. Mayor Houde Welcome of delegates to the meeting and to the Dominion of Canada. Doctor de Gaspe Beaubien, chairman, 1947 summer general meeting committee

Tuesday, June 10

12:00 noon	Regular luncheon. Normandie Roof, Mount Royal Hotel
12:15 p.m.	Golf
3:00 p.m.	Women's fashion show and tea. No charge
8:00 p.m.	Smoker and entertainment. Ballroom and Normandie Roof, Mount Royal Hotel. Tickets: $6
8:30 p.m.	Women's card party and entertainment. No charge

Wednesday, June 11

10:00 a.m.	Laurentian Mountains tour
11:00 a.m.	Dorval Airport. Inspection trip to Shipshaw. Cost: approximately $40 per person
12:00 noon	Regular luncheon. Normandie Roof, Mount Royal Hotel
12:00 noon	Beauharnois inspection trip. Luncheon at Beauharnois power plant. No charge.
12:15 p.m.	Golf
2:00 p.m.	Scenic tour of Montreal. Regular rates
2:00 p.m.	Cyclotron inspection trip

Thursday, June 12

12:00 noon	Regular luncheon. Normandie Roof, Mount Royal Hotel
1:00 p.m.	Women's scenic tour of Montreal. No charge
6:30 p.m.	President's reception
7:30 p.m.	Banquet. Normandie Roof, Mount Royal Hotel. Tickets: $4
10:00 p.m.	Dance. Ballroom, Mount Royal Hotel. Tickets: $1.50

Friday, June 13

12:00 noon	Regular luncheon. Normandie Roof Mount Royal Hotel
12:00 noon	Golf prizes luncheon
6:00 p.m.	Saguenay trip. Boat leaves Montreal and returns to Montreal Monday, June 16, at 8:00 a.m. Cost: $40 to $50 per person

GOLF

Only two scheduled golf events will take place, the competitions for the Mershon Trophy and the Lee Trophy. These two tournaments will be held at the Whitlock Golf Course on Tuesday and Wednesday afternoons, starting at 1:30 p.m. Transportation will be supplied to the course. Busses will leave Mount Royal Hotel at 12:15 p.m.

Mershon Trophy. The four men having the lowest net scores on the first eighteen holes of play will qualify for the final round. Momento will be given to the winner and a prize for the runner-up.

Lee Trophy. Players will be allowed to use their scores for the first 18 holes of this competition as the qualifying round for the Mershon Trophy. Green fees will be $2 per day per player.

Entries. Early registration for golf is requested, so that the committee may make proper arrangements for transportation. Playing rights have been granted for a limited number of players at each of seven other golf clubs. The final round of the Mershon Trophy can be played at any of the clubs at which playing privileges have been obtained.

The golf registration desk will be on the mezzanine floor of the Mount Royal Hotel. Complete and detailed information will be available at the desk on all matters concerning the golfing program.

1947 Year Book Issued. The 1947 edition of the AIEE Year Book has been issued, in accordance with 1946–47 budget provisions. Addresses are corrected as of November 1, 1946. Copies have been distributed to all national, District, and Section officers, Student Branch counselors, and all members of national committees. Other members may obtain copies by writing to the AIEE, 33 West 39th Street, New York 18, N. Y. The Year Book is not available to nonmembers of the AIEE; nor is its use permitted for commercial, promotional, or circularization purposes.

Future AIEE Meetings

Pacific General Meeting
San Diego Hotel, San Diego, Calif., August 26–29, 1947

Middle Eastern District Meeting
Biltmore Hotel, Dayton, Ohio, September 23–25, 1947

Midwest General Meeting
Congress Hotel, Chicago, Ill., November 3–7, 1947

Winter General Meeting
William Penn Hotel, Pittsburgh, Pa., January 26–30, 1948

Shipshaw power development

Program, AIEE Summer General Meeting

Monday, June 9

8:30 a.m. Registration

9:30 a.m. Land Transportation

47-153. Modern Railway Passenger-Car Auxiliary-Power Equipment. **D. R. MacLeod, Jack Hause,** General Electric Company

47-154. The Design of New York Subway Motors for Dynamic Braking. **B. A. Widell,** General Electric Company

47-147. Trolley Coaches and PCC Street Cars Provide Successful City Transportation. **W. J. Clardy,** Westinghouse Electric Corporation

47-155. Proposed Rapid Transit System for Toronto. **W. E. P. Duncan,** Toronto Transportation Commission

47-148. Motor Control for New New York City Transit System Subway Cars. **L. G. Riley,** Westinghouse Electric Corporation

CP.** A Means of Demonstrating the Behavior of Conventional Types of Instruments in Circuits Having Potentials and Currents of Irregular Wave Form. **E. E. Moyer,** General Electric Company

9:30 a.m. Conference on Education

CP.** Graduate Work in Electrical Engineering. **R. W. Sorensen,** California Institute of Technology

CP.** The 5-Year Electrical Engineering Curriculum. **E. E. Dreese,** Ohio State University

CP.** Young Engineers in Industry—Their Collegiate Background and Industrial Training. **H. N. Muller,** Westinghouse Electric Corporation

9:30 a.m. Industrial Voltage Requirements

47-157-ACO.* Report on Industrial Voltage Requirements. An AIEE Committee Report

47-122. Data on the High-Frequency Resistance of Coils. **W. F. Witzig,** Westinghouse Electric Corporation

47-158. Dielectric Heating—the Measurement of Loss Under Rising Temperature. **J. B. Whitehead,** Johns Hopkins University

47-138. Electric Furnace Practice in Canada. **J. L. Balleny,** Canadian General Electric Company, Ltd.

47-159-ACO.* High-Frequency Heating in the Radio Spectrum. **W. C. Rudd,** Induction Heating Corporation

10:30 a.m. Delegates Get-Together

C. S. Purnell, presiding

One of the most important benefits of delegates attending the summer general meeting is the opportunity afforded each delegate to become acquainted personally with the other delegates, Institute officers, and the members of the Sections committee. In the conversations resulting from such acquaintanceships, much information of value is exchanged. The Sections committee members will be present to see that all delegates become acquainted at this informal get-together. This new feature for the delegates will enable them to become acquainted early, so that they may reap the benefits of these acquaintanceships during the entire meeting.

2:00 p.m. Conference on Section Operation and Management

There will be three separate conferences with parallel meetings, one for the larger Sections, one for the intermediate Sections, and one for the smaller Sections. Delegates are requested to attend meeting to which their Section is assigned. There will be no formal presentations at these meetings. Each delegate should come prepared to discuss informally the activities of his Section. The delegates will benefit from these conferences in direct proportion to their participation. Each meeting will be developed by discussion and questions from the floor covering the following subjects:

1. Safety activity
2. Section finance
3. Student activities
4. Subsections

Five-minute intermission: Distribution of travel vouchers to delegates.

5. Educational courses and lectures
6. Prize paper competition
7. Inspection trips and social activities
8. Local councils of engineering and technical societies

Five minute intermission. Collection of signed travel vouchers

9. Section publicity
10. Section programs
11. Fellowship
12. Other activities

Larger Sections

R. M. Pfalzgraff, presiding
W. F. Henn, secretary

Intermediate Sections

G. W. Bower, presiding
H. H. Sheppard, secretary

Smaller Sections

A. C. Muir, presiding
John Gammell, secretary

—PAMPHLET reproductions of author's manuscripts of the numbered papers listed in the program may be obtained as noted in the following paragraphs.

—ABSTRACTS of most papers appear on pages 607–14 of this issue.

—PRICES and instructions for procuring advance copies of these papers accompany the abstracts. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in five-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the technical program committee ultimately will be published in "Proceedings" and "Transactions"; essential substance of many will appear in "Electrical Engineering."

Tuesday, June 10

9:30 a.m. Conference on Student Branches

9:30 a.m. Conference on International Standardization

This conference is sponsored by the Standards committee of the AIEE. The aim will be to collect as much information as possible regarding American and European standards for switchgear, motors, and transformers, and to obtain discussion by international authorities on standardization directed towards a comparison of present standards. It is hoped that the information obtained will be of value to the International Electrotechnical Commission international committees in their future work and to the International Organization for Standardization.

CP.** Address by a representative of the International Organization for Standardization.

CP.** International Electrotechnical Commission. **L. F. Adams,** president, United States National Committee

CP.** **E. C. Crittenden,** past president, United States National Committee, IEC

CP.** Swedish Standards Specifications for High-Voltage Circuit Breakers. **A. U. Lamm,** Allmanna Svenska Elektriska Aktiebolaget

47-161-ACO.* On Definitions of Magnitudes Characterizing the Behavior of Circuit Breakers Under Abnormal Conditions in American and Other Standards. **S. Gerszonowicz,** University of Montevideo

9:30 a.m. Power Supply in Paper Mills

CP.** Power Tie With Utility. **A. P. Schnyder,** G. F. Hardy Company

CP.** High-Voltage Distribution in Paper Mills. **G. H. McHenry, J. L. McKeever,** Canadian General Electric Company

CP.** Low-Voltage Power Distribution in Paper Mills. **A. C. Bird,** Hardy S. Ferguson Company

47-129. Automatic Operation of Electric Boilers. **M. Eaton,** Shawinigan Chemicals Limited

CP.** Electric Boilers from Utility Point of View. **L. B. Stirling,** Shawinigan Water and Power Company

2:00 p.m. Conference of Officers, Delegates, and Members

R. M. Pfalzgraff, presiding
A. C. Muir, secretary

The following items will be presented:

1. Opening remarks by chairman
2. Observations by **J. Elmer Housley**
3. Remarks by **B. D. Hull**
4. AIEE publications services
5. Transfers—a continuing program
6. The Section of Tomorrow (A review of the Sections committee program, projected into the future). **G. W. Bower,** chairman, Sections committee

Ten-minute intermission

7. The District of Tomorrow. **H. H. Henline,** secretary, AIEE
8. Section membership activity and its future possibilities
9. Institute finance and its relation to the Section of tomorrow
10. Educational courses conducted by the Section of tomorrow
11. Section–Branch co-operation—essential to the Institute of tomorrow
12. The Institute of tomorrow

2:00 p.m. Conference on International Standardization

CP.** AIEE Standards for Preferred Voltages. **C. A. Powel,** Westinghouse Electric Corporation

*ACO: Advance copies only available; not intended for publication in *TRANSACTIONS*.
**CP: Conference paper; no advance copies are available; not intended for publication in *TRANSACTIONS*

June 9–13, 1947, Montreal, Canada

CP.** Standards for Induction Motors—American and Foreign. **W. R. Hough,** Reliance Electric and Engineering Company

CP.** A Review of International Transformer Standards and Applications. **A. Boyajian, H. S. Hubbard, H. M. Jalonack, V. M. Montsinger,** General Electric Company

2:00 p.m. Equipment in Paper Mills

47-130. The Application of Synchronous and Induction Motors to Chippers. **R. R. Baker, M. R. Lory,** Westinghouse Electric Corporation

CP.** Electric Equipment for Paper Machines. **H. W. Rogers,** General Electric Company

47-167-ACO.* Electric Equipment in the Finishing Room. **F. Winterburn,** Howard Smith Paper Mills, Ltd.

CP.** Electrical Maintenance in a Newsprint Mill. **John Eyton,** Abitibi Power and Paper Company, Ltd.

Wednesday, June 11

10:00 a.m. Annual Meeting

President **J. Elmer Housley,** presiding

Report of board of directors. **H. H. Henline,** secretary

Report of treasurer, **W. I. Slichter**

Reports of committee of tellers on votes for nominees for AIEE offices

Introduction of, and presentation of president's badge to **Blake D. Hull**

Response by **Mr. Hull**

Report on Institute prizes for papers. **M. D. Hooven,** chairman, committee on award of Institute prizes

Presentation of Lamme Medal to **John B. MacNeill,** manager of the switchgear and control division, Westinghouse Electric Corporation, "for his foresight, leadership, and creative contribution in the development of switching equipment"

The Establishment of the Medal. **John C. Parker,** chairman, Lamme Medal committee

The Career of the Medalist. **S. M. Dean,** chief engineer of the system, Detroit Edison Company

Presentation of medal and certificate by **President Housley**

Response by **Mr. MacNeill**

Any other business that may be presented

President's address. **J. Elmer Housley**

2:00 p.m. Conference on Technical Group Activities in the Sections

A. C. Muir, presiding

R. G. Porter, secretary

1. Opening remarks by chairman

2. The Opportunities of Technical Group Operation. **G. W. Bower,** chairman, Sections committee

3. Description of technical group operating plans of representative Sections and Subsections

Ten minute intermission

4. Co-operation with technical committees of the Institute will be covered by several short talks on the following subjects:

A. Material for use by technical groups and the Sections

B. Reports of technical committee members at technical group or Section meetings

C. Active participation of members of Institute technical committees in the operation of technical groups in the Sections

D. Technical groups as a source of additional technical papers for the Institute

E. Technical groups, a source for members for Institute technical committees

5. Co-operation—A 2-Way Technical Activity. **T. M. Linville,** member, Sections committee

An open discussion after each presentation will be an important feature of this conference. In addition to the delegates, the Section, District, and Institute officers, the chairmen and members of all Institute committees and all other members interested in technical group activities are invited to attend and participate in this discussion

2:00 p.m. Power Transmission and Distribution

47-162. Electronic Stabilizer for Power Transmission. **E. F. W. Alexanderson, D. C. Prince,** General Electric Company

47-164. The Probable Breakdown Voltage of Paper Dielectric Capacitors. **Hamilton Brooks,** Westinghouse Electric Corporation

47-116. Metering With Transformer-Loss Compensators. **G. B. Schleicher,** Philadelphia Electric Company

47-143. Galloping Conductors and a Method for Studying Them. **E. L. Tornquist, C. Becker,** Public Service Company of Northern Illinois

2:00 p.m. Servomechanisms (Closed-Cycle Control Systems)

47-110. Solution of the General Voltage Regulator Problem by Electrical Analogy. **E. L. Harder,** Westinghouse Electric Corporation

47-165. The Analysis and an Optimum Synthesis of Linear Servomechanisms. **Donald Herr, Irving Gerst,** Control Instrument Company, Inc.

CP.** High Accuracy Electric Positioning Systems for Industrial Use. **D. E. Garr,** General Electric Company

CP.** Self-Balancing Recorders as Servomechanisms. **A. J. Williams, Jr.,** Leeds and Northrup Company

2:00 p.m. Modulation

47-150. Modulation in Communication. **Frank A. Cowan,** American Telephone and Telegraph Company

47-166. Distortion and Band Width Characteristics of Pulse Modulation. **H. L. Krauss, P. F. Ordung,** Yale University

47-131. Pulse Code Modulation. **H. S. Black, J. O. Edson,** Bell Telephone Laboratories, Inc.

47-152. Distortion in a Pulse-Count Modulation System. **A. G. Clavier, P. F. Panter, D. D. Grieg,** Federal Telephone and Radio Laboratories

CP.** Demonstration of Various Modulation Methods. **S. M. Findlay,** RCA-Victor of Canada

Thursday, June 12

9:30 a.m. Board of Directors' Meeting

9:30 a.m. Hydroelectric Power Generation

47-120. The Maintenance of Hydroelectric Generating Units. **A. S. Robertson, R. O. Standing,** The Hydro-Electric Power Commission of Ontario

47-124. Hydroelectric Power Development in Quebec. **F. L. Lawton,** Aluminum Company of Canada, Ltd.

47-135. The German Electrical Utility Industry During World War II. **J. G. Noest,** Consolidated Edison Company of New York, Inc.

47-168. Factors in the Economic Supply of Energy in Hydroelectric Systems. **A. H. Frampton, G. D. Floyd,** The Hydro-Electric Power Commission of Ontario

9:30 a.m. Instruments and Measurements

47-119. Quantitative Determination of Magnetic Properties by Use of Cathode-Ray Oscilloscope. **Joseph Zamsky,** Allis-Chalmers Manufacturing Company

47-169. Applications of the Electrodynamic Instrument Mechanism. **A. J. Corson, N. P. Millar,** General Electric Company

47-136. A Self-Balancing Capacitance Bridge. **A. H. Foley,** General Electric Company

47-151. A Simplified Double-Film Klydonograph With an Improved Coupling Method. **J. H. Waghorne,** The Hydro-Electric Power Commission of Ontario

9:30 a.m. Industrial Control Devices

47-133. Dynamic Braking of Two D-C Series Motors. **J. D. Leitch,** The Electric Controller and Manufacturing Company

47-134. Control of Slip Ring Motors by Means of Unbalanced Primary Voltages. **N. L. Schmitz,** Cutler-Hammer, Inc.

47-141. Some Fundamentals of a Theory of the Transductor or Magnetic Amplifier. **A. Uno Lamm,** Allmanna Svenska Elektriska Aktiebolaget

47-128. Rotating Stability Regulators for Synchronous Motor Drives. **W. Schaelchlin,** Westinghouse Electric Corporation

9:30 a.m. Hazards of Static Electricity

CP.** Hazards of Static Electricity With Relation to Explosive Vapors. **J. T. W. Babcock,** Factory Insurance Association

47-172-ACO.* The Hazards of Static Electricity in Grain Handling and Grain Processing Plants. **C. M. Park,** Mutual Fire Prevention Bureau

47-170. Hazards of Static Electricity in Hospital Operating Rooms. **H. B. Williams, M.D.,** Columbia University

12:30 p.m. Board of Directors' Luncheon

2:00 p.m. Power Transmission and Distribution

47-115. Lightning and 60-Cycle Power Tests on Wood-Pole Line Insulation. **P. L. Bellaschi,** Westinghouse Electric Corporation

47-163. Economics of Long-Distance A-C Power Transmission. **S. B. Crary, I. B. Johnson,** General Electric Company

47-114. Lightning Investigation on the 25-Kv System of the West Penn Power Company. **W. C. Bowen,** West Penn Power Company; **Edward Beck,** Westinghouse Electric Corporation

47-117. Performance of Tennessee Valley Authority 161-Kv and 115-Kv Transmission Lines. **K. E. Hapgood, C. P. Almon, Jr.,** Tennessee Valley Authority

2:00 p.m. Communication

47-146. An Electronic Regenerative Repeater for Teletypewriter Signals. **R. B. Hearn,** Bell Telephone Laboratories, Inc.

47-160. An FM Telegraph Terminal Without Relays. **F. H. Cusack, A. E. Michon,** Western Union Telegraph Company.

47-171. The Application of Heterodyne Modulation to Wide-Band Frequency-Modulated Television Relays. **W. P. Boothroyd,** Philco Corporation

47-140-ACO.* Radio Interference Suppression in Canada. **H. O. Merriman,** Canadian Department of Transport

CP.** The Telephone System in Canada. **J. L. Clarke,** The Bell Telephone Company of Canada, Ltd.

2:00 p.m. Power Supply for Resistance Welding

Four papers of the conference type will present the point of view, with respect to this subject, of the utilities, users, control equipment manufacturers, and welding machine manufacturers.

2:00 p.m. Conference on Electrochemical Conversion Equipment

CP.** Electrolytic Zinc at Anaconda: Paralleling of Rectifiers and Rotary Converters. **R. J. Kennard,** Anaconda Copper Mining Company

CP.** Conversion Equipment in the Magnesium Industry. **F. L. Glaza,** Dow Chemical Company

CP.** Conversion Equipment in the Chlorine Industry. **M. S. Kircher, D. O. Hubbard,** Hooker Electrochemical Company

Friday, June 13

9:30 a.m. Conference of Vice-Presidents, District Secretaries, and Incoming Vice-Presidents

9:30 a.m. Electric Machinery and Transformers

47-132. Silicone Insulation as Applied to Naval Electric Power Equipment. **H. P. Walker,** Bureau of Ships, United States Navy Department

47-127. Preliminary Report on Laboratory Aging Tests on Class *A* Insulation. **An AIEE Committee Report**

47-144. High-Voltage Power-Transformer Design—II. **M. B. Mallett,** English Electric Company of Canada, Ltd.

47-139. Typical Transformer Faults and Gas Detector Relay Protection. **J. T. Madill,** Aluminum Company of Canada, Ltd.

9:30 a.m. Power System Applications of Carrier Current

47-112. A New Single-Side-Band Carrier System for Power Lines. **B. E. Lenehan,** Westinghouse Electric Corporation

47-121. TVA Co-ordinated Communication System. **T. DeWitt Talmage,** Tennessee Valley Authority

47-142. Operation of Power Line Carrier Channels. **H. W. Lensner,** Westinghouse Electric Corporation

9:30 a.m. Conference on Electrochemical Conversion Equipment

CP.** Conversion Equipment in the Aluminum Industry in the United States. **Joel Tompkins,** Aluminum Company of America

CP.** Conversion Equipment in the duPont Company. **Harold Houck,** E. I. du Pont de Nemours and Company, Inc.

9:30 a.m. Conference on Large-Scale Computing Devices

CP.** Engineering Applications of Relay Type Computers. **H. W. Bode, E. G. Andrews,** Bell Telephone Laboratories, Inc.
CP**. Engineering Applications of IBM Equipment. **A. W. Rankin,** General Electric Company

2:00 p.m. Electric Machinery

47-123. The Horsepower Output of Polyphase Induction Motors. **R. C. Robinson,** Electric Specialty Company

47-126. Interlaminar Eddy Current Loss in Laminated Cores. **A. C. Beiler, P. L. Schmidt,** Westinghouse Electric Corporation

47-113. Dynamic Brush Characteristics by the Dynamotor Method. **C. J. Herman,** General Electric Company

47-125. Hiperco—A Magnetic Alloy. **J. K. Stanley, T. D. Yensen,** Westinghouse Electric Corporation

2:00 p.m. Conference on Telemetering

47-137. Electronic Telemetering System. **G. E. Foster,** Foster Engineering Company; **W. M. Kiefer,** Commonwealth Edison Company

CP.** The Electrical Impulse Totalizer. **G. E. Foster,** Foster Engineering Company

CP.** Telemetering Applications on Systems of the Hydro-Electric Power Commission of Ontario. **C. K. Duff,** Hydro-Electric Power Commission of Ontario

CP.** The Self-Balancing A-C Bridge in Impulse Duration Telemetering. **G. M. Thynell,** The Bristol Company

CP.** New Devices Derived From a Torque Balance Telemeter. **W. H. Burnham,** General Electric Company

CP.** A Variety of Telemetering Applications. **A. P. Peterson,** Control Corporation

2:00 p.m. Conference on Operation of Mercury-Arc Rectifiers

CP.** Modern Rectifier Station Design. **D. I. Bohn, R. N. Wagner,** Aluminum Company of America

CP.** Rectifier Operation in the Aluminum Company of Canada. **J. W. Ward,** Aluminum Company of Canada

CP.** Rectifier Operation in the Carnegie-Illinois Steel Mills. **F. W. Cramer,** Carnegie-Illinois Steel Corporation

CP.** Rectifier Operation at the Trail Plants of the Consolidated Mining and Smelting Company of Canada Limited. **A. G. Dickinson,** Consolidated Mining and Smelting Company of Canada, Ltd.

2:00 p.m. Protective Devices

47-149. Relay Protection of Power Transformers. **An AIEE Committee Report**

47-118. Selective Tripping of Low-Voltage Air Circuit Breakers. **William Deans,** I-T-E Circuit Breaker Company

47-156-ACO.* A Development in 5,000-Volt Metal-Clad Switchgear. **R. G. Lockett, J. D. Wood,** I-T-E Circuit Breaker Company

47-145. An Improved Overcurrent Tripping Device for Low-Voltage Circuit Breakers. **H. L. Rawlins, Jerome Sandin,** Westinghouse Electric Corporation

47-173. Performance Criteria of D-C Interrupters. **E. W. Boehne,** Massachusetts Institute of Technology; **M. J. Jang,** General Electric Company

AIEE Labor Legislation

Poll and Action Summarized

C. W. Ransom (A '36) AIEE representative on the panel representing the major engineering societies at the Congressional hearing on labor legislation, submitted the following report concerning activities of the panel. Further reference to labor legislation by President J. Elmer Housley can be found on page 598 of this issue.

"The Institute was represented on a labor legislation panel, with five other engineering societies, which testified before the United States Senate and House Labor Committees in March. The panel supported the provisions in Senate bill *360* relating to professional employees, and the House of Representatives bill *1754* which dealt exclusively with collective bargaining practices for professional employees.

"Those bills contained a number of provisions which would render it impossible for heterogeneous collective bargaining organizations to obtain, or retain, collective bargaining rights for professional employees, if the majority (nonsupervisory employees) did not want to be so represented. Provision was also made for the establishment of bargaining units, composed exclusively of professional employees (non supervisory), if the majority so desired.

"Except for indirect implications, these bills did not provide for freedom of relations between unstratified (supervisory and nonsupervisory) groups of professional employees and their managements. Such a law, therefore, would not permit a professional society, such as the Institute, freedom of action on industrial relations problems affecting its membership.

"These bills were supported by the AIEE because of the urgent need to prevent further inclusion of engineers into heterogeneous units against the will of the majority; and because the provision contained in those bills appeared to represent the best improvement that could be made at this time relative to the engineering profession.

"However, subsequent representations suggesting 'optional exemption' from the terms of the act have met with favorable consideration by interested members of the Congress. The omnibus labor House of Representatives bill *3020* passed by the House, April 17, by a vote of 308 to 107 contains such a provision for professional employees, crafts, and other distinguishable groups.

"That bill provides for freedom of choice and action by professional employees (nonsupervisory) who choose to exercise collective bargaining rights, and also permits freedom of action by unstratified

Table I. Analysis of Results in Terms of Employment Status

Employment Status	Number	Per Cent "Yes"	Per Cent "No"
Supervisor	6,767	89	11
Nonsupervisor	7,589	80	20
Consultant	2,474	89	11
Student	3,575	77	23

Note: Some consultants also checked supervisor or nonsupervisor.

Table II. Analysis of Results in Terms of Grade of Membership

Grade	Number	Per Cent "Yes"	Per Cent "No"
Honorary	5	100	0
Fellow	767	95	5
Member	5,296	89	11
Associate	8,628	82	18
Student	3,575	77	23

(supervisory and nonsupervisory) groups and organizations. It is the only bill, introduced to date, designed to give full freedom of association to the engineering personnel.

"The provisions of the new Senate bill *1126* are patterned after the earlier bills, S-360 and H.R.-1754.

"The approach which will be taken by the Senate–House conference committee, in drafting the final bill, is uncertain at the time of this writing.

"The Institute's experience on this problem has been very encouraging. Congress is diligently striving to provide a law which will best serve the interests of the American public. Members of the Senate and House Labor committees have expressed their appreciation of the co-operation of the AIEE membership in supplying the data obtained by the recent opinion poll on this issue.

"That opinion poll questionnaire was submitted to all United States members and student members asking, "Do you favor exempting professional employees from the provisions of the Wagner Act (National Labor Relations Act)?" A summary of the results is as follows:

Number of questionnaires submitted on March 21, 1947	31,081
Number of questionnaires returned by April 27, 1947	18,640
Per cent return	60
Per cent favoring exclusion	84
Per cent opposed to exclusion	16

"The results of this ballot have been submitted to interested members of Congress to convey to them the opinion of the membership. The data provided tangible evidence in support of 'optional exemption,' providing the advantages of exemption and yet retaining full legal protection for those groups desiring to form collective bargaining organizations. Such a provision was written into the House of Representatives bill *3020*."

Table III. Analysis of Results in Terms of Age Groups

Age	Number	Per Cent "Yes"	Per Cent "No"
Under 26	3,289	79	21
26–35	5,174	79	21
36–45	4,269	86	14
Over 45	5,745	91	9

Note: Because the per cent "Yes" responses increase with "age," and since the average age of the supervisory group may be appreciably greater than that of the nonsupervisory group, it is probable that if the results given in Table I were corrected for the "age factor," the actual difference attributable to supervisory status would be less than indicated by that tabulation.

Second Order Form Appears for AIEE PROCEEDINGS

North Eastern District and summer general meeting papers are included in the second AIEE *PROCEEDINGS* order form which appears on pages 55A–56A of this issue. This new series of publications, designed for the specialist to whom early availability of the full text of technical papers is of special importance, constitutes a special service to AIEE members and is not available for general distribution. Details of the current AIEE publications policy in this regard are given in the January issue on page 82.

Most papers will appear in digest or abbreviated form in future issues of *ELECTRICAL ENGINEERING*, and all will be included in the annual bound *TRANSACTIONS* volume. Because discussions are being included in the *PROCEEDINGS* sections, distribution necessarily will be delayed for some time after formal presentation of the paper in order to allow for publication processing of the discussion.

The first AIEE *PROCEEDINGS* order form appeared in the February issue on pages 33A and 34A of the advertising section, and distribution of the items listed now is well under way.

AIEE Participates in National Conference on UNESCO

A national conference was held in Philadelphia, Pa., on March 24–26, 1947, under the auspices of the United States National Commission for the United Nations Educational, Scientific, and Cultural Organization, called UNESCO, to which approximately 1000 national organizations sent representatives.

UNESCO is one of the specialized agencies of the Economic and Social Council under the General Assembly of the United Nations. The first conference of UNESCO was held in Paris in November 1946, when the structure of the new organization was defined, and the executive board and director-general were appointed. Archibald MacLeish represents the United States on the 18-member executive board, and Doctor Julian Huxley, of the United Kingdom, was appointed director-general, with Walter H. C. Laves, of the United States, as deputy director-general.

The United States membership in UNESCO was authorized by Public Law *565*, signed by President Truman on July 30, 1946. On that occasion, the President said:

"UNESCO will summon to service in the cause of peace the forces of education, science, learning, the creative arts, and the agencies of the film, the radio, and the printed word through which knowledge and ideas are diffused among mankind.

"The Government of the United States will work with and through UNESCO to the end that the minds of all people may be freed from ignorance, prejudice, suspicion, and fear, and that men may be educated for justice, liberty, and peace. If peace is to endure education must establish the moral unity of mankind."

The Philadelphia meeting was devoted to the program of UNESCO, and the development of co-operation with the various educational, scientific, and cultural organizations in the United States.

Among the 13 projects which form the basic program of UNESCO are:

1. Plans for a *world-wide attack on illiteracy*, with the development of a program of "fundamental education" and the establishment of minimal educational standards.

2. *Plans for a comprehensive revision of textbooks and teaching materials* in the interest of international truthfulness, international understanding, and international peace.

3. *A study preliminary to the employment, on a planetary scale and for the purpose of planetary understanding, of the new and revolutionary developments in mass communication* which have made it possible, for the first time in human history, to conceive of culture in planetary terms. A world-wide radio network at the disposition of UNESCO and the United Nations is one of the possibilities which will be investigated.

4. *A study, in collaboration with other United Nations organizations, of the urgent scientific problems arising in those regions of the earth where a majority of the population is undernourished.*

5. *International exchange of persons* representative of the lives and cultures of their peoples, particularly with a view to re-establishing the trained personnel needed for teaching and study, and to facilitate direct human relationships between students and specialists and scholars and technicians and workers in the several nations.

6. *The establishment of an international interlibrary loan system* to make printed materials in any part of the earth accessible, in original or copy, to readers in any other part of the earth.

Under this general program, UNESCO desires to encourage on the widest international basis the exchange of instructors and trainees in the technical field. It is proposed that:

UNESCO, in the interests of those countries trying to create, extend, or improve their own mass media, should operate a scheme whereby countries with the best technical resources would give to countries less favored the benefits of their experience by training guest-personnel in the various fields.

For this purpose fellowships should be established either by the host-countries, through government or nongovernment bodies, or, where necessary, by UNESCO itself.

Simultaneously, a higher order of fellowships should be established which would enable qualified practitioners in the fields of mass media to have "refresher courses" in countries other than their own.

The leadership in this whole program of international co-operation necessarily rests with the Department of State. To carry out this responsibility, Acting Secretary Acheson sent to Congress on March 24 a proposed measure authorizing on a world-wide basis the four types of cultural and informational activities which have been carried on over a period of years with Latin America; that is:

1. Educational exchanges of students and professors, books, and other educational materials.

2. Assignment of Government specialists abroad to advise foreign governments on problems in such fields as agriculture, public health, census taking, child welfare, and civil aviation safety.

3. Joint scientific services, such as international weather stations and tidal survey work to aid American shipping and aviation.

4. International information activities such as world-wide radio broadcasting, maintenance of American libraries in some 60 of our embassies and consulates, and the furnishing of documentary motion pictures for showing in public institutions abroad.

It is hoped that the many independent organizations represented at the meeting, such as the AIEE, will each in its own way carry on this work of improved international understanding and mutual aid.

P. L. Alger (F '30) and H. C. Dean (F '30) who attended the meeting as AIEE representatives, by appointment of President Housley (F '43), have suggested that this brief report be published in *ELECTRICAL ENGINEERING*, so that the Institute's part in the UNESCO program may be given full consideration by the members.

Middle Eastern District Plans for Fall Meeting

An interesting and informative program is being arranged for the Middle Eastern District meeting, which will be held September 23–25, 1947, at the Hotel Biltmore, Dayton, Ohio.

Several fine inspection trips have been arranged for the convention, giving convention delegates an opportunity to tour several interesting installations. On Wednesday, visitors will have their choice among McCall Corporation, Delco Products, The National Cash Register Company, and Dayton Rubber Company.

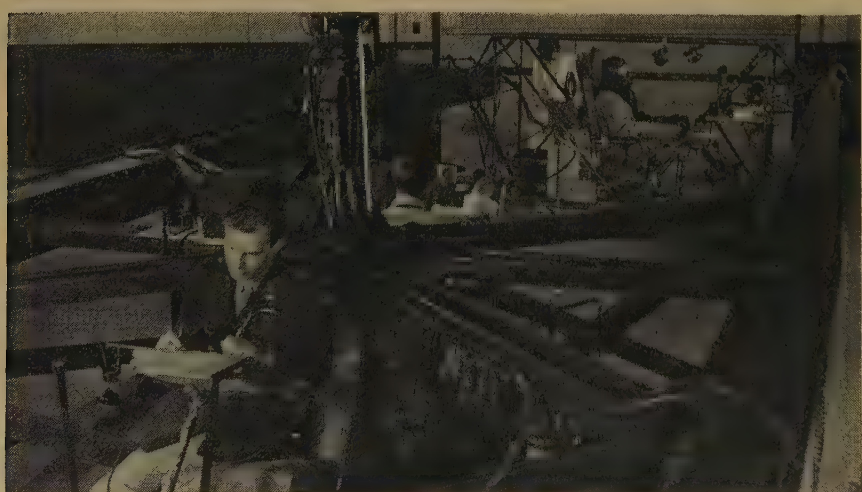
The District executive committee will meet all day Monday, September 22, with the convention formally scheduled to open at 9:30 a.m. Tuesday, September 23, with Milton Wagner (F '30) presiding. Leakage reactance of motors will be discussed at the morning session, and the afternoon will be devoted to sessions on the general development of air transportation, and electric machinery.

Discussions on motor design of electric machinery will open the Wednesday morning session, and will be followed by sessions on industrial electronics, and current projects of air transportation. The tours take up Wednesday afternoon.

Thursday morning will be devoted to meetings on air traffic and testing electric machinery, and the afternoon and final session will be given over to the tour of Wright Field.

Dayton is noted as the home of aviation, for it was in Dayton that Orville and Wilbur Wright pioneered the first airplane. Dayton is also recognized as a great industrial center, and it is claimed that more electric motors are manufactured there than any other city in the world. Other industries in Dayton produce cash registers, accounting machines, mechanical refrigerators, automotive components, rubber products, and print many world-read magazines.

In addition to the tours, which should prove as entertaining as they will be educational, the program committee has provided for a get-acquainted smoker Tuesday night, and a dinner meeting Wednesday night, with many widely known men scheduled to speak, and considerable entertainment scheduled.



Human centrifuge at Wright Field medical laboratory

1947 Lamme Medal Nominations Due December 1

Special attention is directed to the fact that the names of Institute members who are considered eligible for the AIEE Lamme Medal, to be awarded early in 1948, may be submitted by any member in accordance with section 1 of article VI of the bylaws of the Lamme Medal committee, as follows:

The committee shall cause to be published in one or more issues of *ELECTRICAL ENGINEERING*, or of its successors, each year, preferably including the June issue, a statement regarding the Lamme Medal and an invitation for any member to present to the secretary of the Institute by December 1, the name of a member as a nominee for the medal, accompanied by a statement of his "meritorious achievement" and the names of at least three engineers of standing who are familiar with the achievement.

Each nomination should give concisely the specific grounds upon which the award is proposed, and also a complete detailed statement of the achievements of the nominee, to enable the committee to determine its significance as compared with the achievements of other nominees. If the work of the nominee has been of a somewhat general character in co-operation with others, specific information should be given regarding his individual contributions. Names of endorsers should be given as specified in the foregoing quotation.

Pacific General Meeting Arrangements Being Made

Arrangements are being made for a program of timely technical interest for the Pacific general meeting to be held in San Diego, Calif., August 26–30, 1947. Headquarters of the meeting will be in the San Diego Hotel. Eight technical sessions, including a student session, will embrace a variety of subject matter. For entertainment there will be a president's reception and cocktail party, a dinner in old Mexico at Serena's, and an informal banquet. The golf tournament will be on Thursday, and prizes will be presented at the evening banquet. In addition to the banquet and other events, special entertainment and trips will be arranged for women attending the meeting.

Tentative Schedule of Events

Tuesday, August 26

8:00 a.m.	Registration (also from 6:00 p.m. to 9:00 p.m. on preceding evening)
9:30 a.m.	Opening general meeting
10:30 a.m.	Technical papers session
12:00 m.	Luncheon at the Electric Club of San Diego
1:30 p.m.	Inspection trip
2:00 p.m.	Women's trip to Point Loma
2:00 p.m.	Technical papers session
6:00 p.m.	President's reception and cocktail party

Wednesday, August 27

9:00 a.m.	Registration
9:30 a.m.	Inspection trip
9:30 a.m.	Student's technical papers session
12:00 m.	Luncheon and speaker
12:30 p.m.	Women's luncheon and bridge party
2:30 p.m.	Inspection trip
2:30 p.m.	Technical papers session
6:00 p.m.	"A Night in Mexico," a dinner in old Mexico at Serena's, with round-trip transportation provided

Thursday, August 28

9:00 a.m.	Registration
8:00 a.m.	Golf tournament (first half)
9:30 a.m.	Technical papers session
11:30 a.m.	Boat ride around the bay with picnic luncheon. Women invited.
2:00 p.m.	Golf tournament (second half)
2:00 p.m.	Technical papers session
7:00 p.m.	Banquet (informal). Awarding of prizes. Speaker.

Friday, August 29

9:00 a.m.	Registration
9:30 a.m.	Technical papers session
10:00 a.m.	Inspection trip
2:00 p.m.	Technical papers session
2:30 p.m.	Inspection trip

Saturday, August 30

A trip to the Palomar Observatory will be arranged, if sufficient interest is shown. A deep-sea fishing trip also will be arranged for those who desire to go fishing.

Fortescue Fellowships Presented for 1947–48

Fellowships sponsored by AIEE since 1939 as a memorial to Charles LeGeyt Fortescue in recognition of his valuable contributions to the electric power industry have been awarded for the academic year 1947–48. The records of five applicants for fellowships were considered and two were selected.

Theodore G. Mihran (Student Member), a resident of Tucson, Ariz., was voted a fellowship in the amount of $500 for graduate study at Stanford University, Palo Alto, Calif., where he received a bachelor's degree in electrical engineering in 1944 and a master's degree in 1947. Mr. Mihran is a member of Phi Beta Kappa and Tau Beta Pi.

Paul Kaczmarczik, a resident of Philadelphia, Pa., was voted a fellowship in the amount of $500 for graduate study at the University of Pennsylvania, Philadelphia. He will receive a bachelor's degree in electrical engineering this year at Drexel Institute, Philadelphia, where he is a member of Phi Beta Kappa, Tau Beta Pi, and Eta Kappa Nu.

Collective Bargaining Pamphlets Available

After a recommendation of the AIEE committee on collective bargaining made before the June 27, 1946, meeting of the AIEE Board of Directors (*EE, Aug-Sept '46, p 409*), work was started on Part I of "Manual on Collective Bargaining for Professional Employees." Publication of this manual originally was recommended by the committee on collective bargaining in a report (*EE, July '45, pp 239–45*) made after careful inquiry into membership practice of unions and prevailing Government attitudes and policy considering all the implications of the engineer's bargaining position in industry.

The manual is being prepared as a joint undertaking of the societies participating in the work of the Committee on the Economic Status of the Engineer. Publication of Part I of the manual in pamphlet form has been rushed in view of the present legislation involving the Wagner National Labor Relations Act. The pamphlet is available from the AIEE Order Department, 33 West 39th Street, New York 18, N. Y., for $1.00.

AIEE Board Approves Committee on NLRA, Twelve Technical, One General Committee

At its regular meeting held April 23, 1947, in Worcester, Mass., the AIEE board of directors authorized the president to appoint a special committee on legislation to assist him in the attempt to effect a satisfactory revision of the National Labor Relations Act. The board thus rescinded its limiting January resolution to conform to the majority opinion expressed in the recent poll of AIEE membership, which favored exemption of engineers from the collective bargaining provisions of the NLRA.

TECHNICAL ACTIVITIES

A number of recommendations of the technical activities subcommittee of the committee on planning and co-ordination were adopted by the board. The chairman of the committee on research was added to the list of ex officio members of the technical program committee. Establishment of the four technical co-ordinating committees that have been in informal operation during the past year (*EE, Jan '47, pages 81–2*) was approved formally with the following designations: industry, power, communication and science, and general applications co-ordinating committees.

The following new technical committees are to be included in the power group:

1. Power systems application of carrier current committee (formerly a joint subcommittee of several technical committees).

2. Power converters—electronics committee (formerly a subcommittee of the committee on electronics).

Five power group technical committees were retired and replaced with ten new technical committees:

Retired Committees	Substituted Committees
Automatic stations	Power substations
Electric machinery	Power rotating machinery
	Power transformers and regulators
Power generation	Power generation
	Power system operation
Power transmission and distribution	Power transmission and distribution systems
	Insulated power cables
Protective devices	Power protective devices
	Power switchgear
	Power relays

In view of the new arrangements of committees which have been made in the past year, the board modified the resolution regarding technical activities of the Institute adopted in May 1946 to read:

RESOLVED that it is the sense of the board of directors that the development of the technical activities of the Institute should be guided by the following principles: (1) that such additional technical committees should be organized as may be needed to cover the important items of electrical technology; (2) that these technical committees should be grouped in appropriate divisions or groups with a co-ordinating committee for each group fairly compact in numbers and consisting essentially of a group chairman and the chairmen of the technical committees comprising the group; (3) that each year the group co-ordinating committees make informal recommendations to the presidential nominee through the secretary on the membership and organization of the whole technical committee structure, including at least two alternates for every co-ordinating committee chairmanship; (4) that in such recommendations a reasonable turnover of the committee personnel be the intention. Further, that it is the intent of this board that the responsible committees should proceed with such changes as they may determine to be necessary and proper to effectuate these principles, unless the proposed changes are at variance with either the constitution or the bylaws, in which event they shall be referred back to the board for further consideration.

GENERAL COMMITTEES

Upon recommendation of the committee on planning and co-ordination and its subcommittee on professional activities, the board authorized the establishment of a general committee on management, with the following scope:

The committee on management shall consider problems of management, including methods of organizing men, money, materials, and research activities; personnel relations and relations between government, industry, and educational or scientific institutions, so far as they may be of importance to electrical engineers. The committee from time to time shall arrange general meeting programs or conferences, shall propose articles of general interest or educational values for publication in *ELECTRICAL ENGINEERING*, and shall co-operate with similar committees in other organizations.

Also at the suggestion of the committee on planning and co-ordination, the board approved the principle of divisional organization of the Institute committees and directed that appropriate steps be taken to work out details and implement this principle during the coming administrative year. This involves the arrangement of the general committees in two divisions, one administrative and the other professional.

SECTIONS

Establishment of the following new Sections was authorized: Arrowhead (formerly a Subsection of the Minnesota Section), Rock River Valley (formerly a Subsection of the Madison Section), and Little Rock (formerly a Subsection of the Memphis Section).

MEETINGS

Reconsidering its action in January postponing such a meeting, the board voted to hold the 1948 summer general meeting in Mexico, Federal District, Mexico, June 21–25.

A North Eastern District meeting in New Haven, Conn., April 28–30, 1948, was authorized.

STANDARDS

Upon recommendation of the Standards committee, the board:

Approved a revision of AIEE Standard 1, "General Principles Upon Which Temperature Limits Are Based in the Rating of Electric Machines and Apparatus," developed by Standards co-ordinating committee 4.

Approved for publication as an AIEE Standard, Report 40, "Electrical Recording Instruments," developed by a subcommittee of the instruments and measurements committee.

Approved for publication as an AIEE Standard, Report 700, "Aircraft D-C Apparatus Voltage Ratings," developed by the committee on air transportation.

Approved for publication as an AIEE Code, "Master Test Code for Resistance Measurements," developed by a subcommittee of the committee on instruments and measurements.

H. B. Gear (F '20) was reappointed a representative of the Institute on the Washington Award Commission for the

2-year term beginning June 1, 1947.

J. W. Barker (F '30) was nominated for appointment by the board of trustees of the United Engineering Trustees, Inc., as a member of The Engineering Foundation board, for the term of four years beginning October 1, 1947.

Professor M. G. Malti (M '45) was appointed as liaison representative to co-operate with the *Quarterly of Applied Mathematics*, to succeed Professor J. G. Brainerd (M '39) resigned.

Present at the meeting were:

President—J. Elmer Housley, Alcoa, Tenn. *Past Presidents*—C. A. Powel, East Pittsburgh, Pa.; W. E. Wickenden, Cleveland, Ohio. *Vice-Presidents*—R. F. Danner, Oklahoma City, Okla.; E. W. Davis, Cambridge, Mass.; T. G. LeClair, Chicago, Ill.; L. M. Robertson, Denver, Colo.; H. B. Wolf, Charlotte, N. C. *Directors*—P. L. Alger, Schenectady, N. Y.; J. F. Fairman, New York, N. Y.; R. T. Henry, Buffalo, N. Y.; C. M. Laffoon, East Pittsburgh, Pa.; M. J. McHenry, Toronto, Ontario, Canada; C. W. Mier, Dallas, Tex.; S. H. Mortensen, Milwaukee, Wis.; J. R. North, Jackson, Mich.; D. A. Quarles, New York, N. Y.; Walter C. Smith, San Francisco, Calif.; E. P. Yerkes, Philadelphia, Pa. *Treasurer*—W. I. Slichter, New York, N. Y. *Secretary*—H. H. Henline, New York, N. Y.

Present by invitation during discussions of their reports were C. W. Ransom (A '36) AIEE representative on the Engineers Joint Council's panel on labor legislation; M. D. Hooven (F '44) chairman, technical activities subcommittee of the committee on planning and co-ordination; C. F. Wagner (F '40) chairman, publication committee.

Records Set by North Eastern District at Worcester Meeting

With a verified registration of 828 persons, the AIEE North Eastern District meeting held in Worcester, Mass., April 23–25, 1947, established a new all-time high record for such meetings in that District. The District meeting idea originated in that District 23 years ago. Detailed statistics are given in accompanying tabulations. This Worcester meeting is the second largest of any AIEE District meetings, being exceeded only by the 900 recorded for the Great Lakes District meeting in Chicago, Ill., in 1927.

At a general session held during the forenoon of the middle day of the meeting, presided over by AIEE Vice-President E. W. Davis (F '34) of the North Eastern District, the time was divided about equally between a report and discussion of AIEE activities, and an address on atomic energy. President J. Elmer Housley (F '43) discussed AIEE activities as he had found them in his country-wide visits to local Sections and Student Branches, dwelling at some length upon the first membership questionnaire and other activities with reference to labor legislation that have taken place since the enabling action of the AIEE board of directors at its January meeting in New York. With reference to labor legislation, President Housley particularly stressed the fact that his AIEE policy and efforts are being directed toward securing legislative changes that will protect the interest of the entire membership—not only the 85 per cent majority which has expressed a desire for complete exemption from all provisions of the Wagner Act or other related acts, and the 15 per cent minority which has indicated a desire to retain access to some or all of the provisions of such act—by working for "optional exemption" which will leave the final such choice in any local situation to the individual engineer. James F. Fairman (F '35) of the New York Section, a director of the Institute, and chairman of the committee on planning and co-ordination reported upon and discussed at some length the activities of his two subcommittees during the past year, the subcommittee on professional activities and the subcommittee on technical activities. The subjects covered by President Housley and Mr. Fairman have been or will be duly reported upon in detail in the news columns of *ELECTRICAL ENGINEERING*.

Harry A. Winne (F '45) vice-president of the General Electric Company, Schenectady, N. Y., in an address, "Atomic Energy—Some of Its Problems and Possibilities," presented a sober, factual recapitulation of this subject which has caught so widely the public fancy and stirred the public imagination in the last two years. This address is scheduled for publication in an early issue of *ELECTRICAL ENGINEERING*.

TECHNICAL PROGRAM

A total of eight technical sessions, running two and three in parallel, provided opportunity for the presentation and the discussion of 34 papers. In addition to these, two student technical sessions, held Friday morning as a part of the District Student Branch annual conference, accommodated the presentation and discussion of 13 student technical papers.

These activities are reported upon in some detail, session by session, on pages 599–606 of this issue.

DISTRICT PRIZES AWARDED

For papers presented at the 1946 North Eastern District meeting in Buffalo, prize winners were announced at the Worcester District meeting banquet April 24. District Secretary Victor Siegfried (M '38) announced the winners, and Vice-President E. W. Davis made the awards as follows:

District prize for best paper, $25 and certificates, to J. E. Sowers, Jr. (M '43) general foreman, electric department, Bethlehem Steel Company, Lackawanna, N. Y., and V. A. Leitzke (A '41) General Electric Company, Buffalo, N. Y., for their paper "A Hot-Strip Mill Flying-Shear Control Providing an Electric Tie Between Mill and Shear."

District prize for best initial paper, $25 and certificate, to Carl L. Frederick (M '46) vice-president and head of engineering physics division, Fredric Flader, Inc., North Tonawanda, N. Y., for his paper "Radio Telemetering for Testing Aircraft in Flight" prepared while he was physicist for Cornell Aeronautical Laboratory, Buffalo, N. Y.

District prize for best Student Branch paper, $25 and certificate to Thomas M. McCaw, Student Member, Worcester (Mass.) Polytechnic Institute for his paper "An Exposure-Color Temperature Meter." This paper, revised, was represented to an appreciative audience at one of the technical sessions of the Worcester meeting.

ENTERTAINMENT

Top feature of the generous entertainment program was the informal banquet attended by some 175 persons, held the evening of the second day of the meeting in the ballroom of the Sheraton Hotel, meeting headquarters. The meeting was presided over by Vice-President E. W. Davis. Professor W. H. Timbie (F '24) of Massachusetts Institute of Technology, Cambridge, AIEE past vice-president (1934–1936), and over the years an inspired and inspiring leader in AIEE activities, swung the gavel as toastmaster with his usual verve. Feature speaker of the evening was Doctor Samuel Van Valkenburg, director of the graduate school of geography, Clark University, Worcester, Mass. Doctor Van Valkenburg, speaking on the topic "The European Puzzle", captured and held his audience's rapt attention by a most illuminating and informative discourse concerning the extent to which displaced persons and deep traditional hatred constitute a major problem and a controlling influence which inestimably complicates the problem of establishing a lasting peace and a stable economy in Europe. Music during the dinner was furnished by the Mildred Barrett Bigelow Trio. Music after dinner was furnished by the Worcester Polytechnic Institute Octet, the boys performing in various combinations to the immense satisfaction of the appreciative audience.

A smoker held the evening of the first day drew 140 men while the women were being entertained by an afternoon-evening sightseeing trip to the historic Wayside Inn, with entertainment and dinner at the inn. The inn, at Sudsbury, Mass., was made famous by Longfellow's "Tales;" now is owned by Henry Ford Estate. The women's program also included a sightseeing tour to the Worcester Art Museum and Higgins Armor Museum, followed by entertainment and tea.

EXECUTIVE MEETINGS

The AIEE board of directors held its spring meeting at Worcester during the first day of the District meeting, repeating the practice of last year when the board met in Asheville, N. C., in connection with the AIEE Southern District meeting. This was a busy, all-day session.

The North Eastern District executive committee held a regular business session which began with luncheon the second day of the meeting and extended throughout the afternoon.

A business conference of Student Branch

North Eastern District Meeting Attendance 1937–47

Date	Location	Attendance
1947—Apr. 23–25	Worcester, Mass.	828
1946—Apr. 24–26	Buffalo, N. Y.	439
1944—Apr. 19–20	Boston, Mass.	630
1943—Apr. 8–9	Pittsfield, Mass.	319
1942—Apr. 29–May 1	Schenectady, N. Y.	481
1941—Apr. 30–May 2	Rochester, N. Y.	355
1939—May 3–5	Springfield, Mass.	439
1938—May 18–20	Lenox, Mass.	417
1937—May 5–7	Buffalo, N. Y.	352

chairmen and counselors was held at a luncheon meeting, the third day of the District meeting.

Reports appropriately covering the business of these meetings will be reported elsewhere in the news columns of this issue or in later issues, as the information becomes available.

INSPECTION TRIPS

A well co-ordinated program of nine major inspection trips, as provided by the local committee, was concentrated in the afternoon of the third day of the meeting and arranged to return visitors in time to make outgoing evening train connections. These main trips included the following (each trip was the responsibility of an individual "plant chairman" who was responsible for arrangement and execution of all the details in connection with his particular trip):

1. Norton Company of Greendale, Mass., where the inspection included many machine tool applications involved in the manufacture of abrasives, ceramics, grinding machines, and other related projects. Attendance 44. Harry Howard, plant chairman.

2. Heald Machine Company of Greendale, Mass., where inspection covered the manufacture of precision and automatic boring machines and other such products, and specifically included some of the machinery discussed in papers presented at the technical sessions. Attendance 24. Robert Heald, plant chairman.

3. Transmitters for radio station *WTAG* and *WTAG-FM* at Holden, Mass., where the inspection included the transmitters and 5-tower radiator array for broadcasting in a directional pattern with variation in pattern for day and night service. Attendance 44. E. A. Browning, plant chairman.

4. Alden Hydraulics Laboratory of Worcester (Mass.) Polytechnic Institute, a proving ground where original work on many of the larger hydroelectric developments in America has been carried on with scale models. Attendance 44. Charles M. Allen, plant chairman.

5. American Steel and Wire Company, Worcester (Mass.) plant, where the inspection included annealing, tinning, and cold rolling departments; stranding, weatherproofing, and insulating processes; lead presses, armoring, rubber mixing, synthetic resin equipment, and other operations incidental to the manufacture of steel and copper wire products including insulated wires and cables. Attendance 83. R. H. Bryant (M '29), plant chairman.

6. New England Power Company substation and load dispatching center at Millbury, Mass., a 110-kv substation and a dispatching center for the power company's entire system. Attendance 44. C. P. Corey, plant chairman.

7. Wyman-Gordon Products Corporation at Grafton, Mass., where inspection included what is reported as being the largest press in the United States for the forging of aluminum and magnesium, and related intricate control features. Attendance 20. G. W. Motherwell, plant chairman.

8. Electronic laboratory of the Worcester (Mass.) County Electric Company where inspection included facilities for meter calibration and for the handling of customer problems in the field of industrial heating, including demonstration equipment. Attendance 29. E. D. Learned, plant chairman.

9. Electrical engineering building at Worcester (Mass.) Polytechnic Institute including electronics and machinery laboratories, and equipment. Attendance 29. T. H. Morgan (F '39), plant chairman.

Analysis of Registration at Worcester

Classification	Worcester Section	District 1*	Other Districts	Totals
Members	36	213	35	284
Student members	28	141	5	174
Men guests	83	227	21	331
Women guests	17	20	2	39
Totals	164	601	63	828

* Outside Worcester.

WHO DID THE WORK?

The secret of success in activities such as the District meeting at Worcester lies in the effective combination of people, enthusiasm, and hard work. For the Worcester meeting, the following people were directly responsible:

District Meeting Committees: District officers, E. W. Davis, *vice-president;* B. F. Hammarstrom, *secretary-treasurer;* technical program, Victor Siegfried; inspection trips and transportation, L. S. Leavitt; hotel and registration, A. L. Duna; entertainment, J. F. Adams; finance, S. M. Anson; publicity and printing, W. W. Locke; Student activities, E. R. McKee; ladies' program, Mrs. W. T. Pierce; and D. G. MacMillan, D. R. Percival, and D. C. Alexander.

North Eastern District Student Conference at Worcester

Student participation in the North Eastern District meeting at Worcester is reported on page 605 of this issue as a part of the report of the Worcester District meeting.

The official executive meeting of Student Branch counselors and Student Branch chairmen for the District was held at a luncheon meeting at the Sheraton Hotel in Worcester, Friday, April 25. Dean E. R. McKee (M '36) of the University of Vermont, Burlington, and chairman of the District committee on student activities presided. Authorized representatives were present as follows: H. B. French, chairman, F. N. Tompkins, counselor, Brown University, Providence, R. I.; R. A. Handy, chairman, G. S. Timoshenko, counselor, University of Connecticut, Storrs; C. H. Stanford, chairman, B. K. Northrop, counselor, Cornell University, Ithaca, N. Y.; A. W. Hamlin, chairman, University of Maine, Orono; C. M. Thing, chairman, W. B. Nulsen, counselor, University of New Hampshire, Durham; F. P. Oresteen, chairman, R. S. Porter, counselor, Northeastern University, Boston, Mass.; J. C. Bonney, chairman, Norwich University, Northfield, Vt.; J. E. Barth, chairman, E. D. Broadwell, counselor, Rensselaer Polytechnic Institute, Troy, N. Y.; R. L. Schantz, chairman, L. A. Mullin, counselor, Syracuse (N. Y.) University, G. G. Mead, Jr., chairman, Union College, Schenectady, N. Y.; D. L. Liston, chairman, University of Vermont, Burlington.

Visitors included National Secretary H. H. Henline (F '43), Vice-President E. W. Davis (F '34), Past Vice-President (1936–38) A. C. Stevens (M '26) of Schenectady, N. Y., and Editor G. R. Henninger (F '43).

Chairman McKee extended the invitation of the University of Vermont, Burlington, to hold the 1949 District Students conference at Burlington, Vt., as a District meeting that year will be consolidated with the national summer general meeting at Swampscott, Mass.

Student Branches were advised of the plans being developed by Sections of the North Eastern District to stand ready to assist Student Branches in securing industrial speakers, also in other ways if requested. Student Branches were urged to establish and maintain liaison with their nearest Section.

Each Student Branch was urged to establish and maintain a complete and up-to-date list of its active enrolled membership at all times. This was emphasized as being the special responsibility of each individual Student Branch counselor.

A discussion of ways and means of establishing a closer working relationship between AIEE Sections and Student Branches in the District brought forth reports including the following interesting activities:

Boston Section has encouraged students to take an active part in both Section and technical group meetings with mutually favorable results; also, students have given direct assistance to the Section by performing such functions as the operation of projection machines at meetings. Ithaca Section has provided for Student Branch meetings panels of professors for the open discussions of topics of current interest, such as the relative value of optional courses offered in the curricula, and labor and industrial relations; also held a very successful "father and son" banquet with the Section members serving as "fathers" for the "sons" of the Student Branches.

A question raised as to whether freshmen and sophomore students at junior colleges or 2-year veteran institutions should be admitted as AIEE Student Members if such students declare their intention of going later to a school sponsoring a full ECPD-accredited school without fault received an emphatic ten-to-one negative vote.

A discussion of the present AIEE publication policy, engaged in at some length, brought an informal vote of seven-to-three favoring the current publication policy which went into effect in January 1947.

Each Student Branch in the District was urged to study the reports published in *ELECTRICAL ENGINEERING* currently covering the studies of the planning and co-ordination committee, subcommittees on professional activities and technical activities, for the purpose of reflecting to AIEE headquarters any views and recommendations concerning AIEE activities which might arise from such student discussions. Only mild interest was evidenced in this project.

Dean McKee's report stated that only 8 of the 18 Student Branches in the North

Eastern District had submitted yearly summary reports as requested. These 8 Student Branches reported 51 Branch meetings with an over-all average attendance of 101 persons per meeting; top attendance recorded by Rensselaer Polytechnic Institute Branch with 2,594 for the "House of Magic" show; number of meetings per branch ranged from 4 to 11; of the 51 reported meetings, 2 featured motion pictures, 10 featured inspection trips, 31 presented outside papers, 5 presented student speakers, and business meetings accounted for 3.

The subject of joint AIEE-IRE Student Branches was brought up for consideration, but seemed to be of relatively little general interest. Casual discussion of this subject seemed to indicate that whereas one or two persons apparently were interested in stipulating the formation of single joint organizations among electrical engineering students, the majority preferred separately organized groups between which joint meetings could be arranged appropriately when subject matter of broad, common interest is planned by either group. This latter plan is believed by many to be preferable because it affords double the opportunity for the individual participation of students in such organizational and administrative activity, also provides for a flexibility of program which enables each group to pursue technical subject matter not of especial interest to the other group but at the same time to get together for joint activities of mutual interest.

North Eastern District Executive Committee Meets at Worcester

The regular spring meeting of the North Eastern District executive committee was held Thursday, April 24, 1947, at the Hotel Sheraton, Worcester, Mass., incidental to the District meeting, beginning at noon with luncheon and extending through most of the afternoon.

ATTENDANCE

All District executive committee officers were present: Chairman E. W. Davis (F '34) of the Cambridge Section; District Secretary Victor Siegfried (M '38) of the Worcester Section; Dean E. R. McKee (M '30), Pittsfield Section, chairman, District committee on student activities. Sections were represented as follows: Boston—Professor T. S. Gray, Section chairman, F. S. Bacon, Jr., District vice-chairman of membership; Connecticut—H. F. Brown, Section chairman; Ithaca—W. H. Erickson, Section chairman; Lynn—R. G. Slauer, incoming Section secretary-treasurer; Niagara Frontier—R. G. Harper, Section chairman; Pittsfield—D. D. McCarthy, Section chairman; W. E. Birchard, Section secretary-treasurer, W. S. Fielding; Providence—C. H. Parker, Section chairman; Rochester—G. R. Town, Section chairman, A. F. Martin, Section secretary; Schenectady—R. V. Shepherd, Section chairman, B. H. Caldwell, Jr., incoming Section chairman; Syracuse—L. J. Audlin, Section chairman, L. M. Moore; Worcester—Professor T. H. Morgan, Section chairman, B. F. Hammarstrom, Section secretary.

AGENDA

The following 16 items constituted the agenda for the meeting. All came in for a full share in the discussion. The principal actions taken are indicated.

1. Opening remarks and review of actions of board of directors, by Vice-President Davis.

2. Readings from national officers.
Secretary Henline (F '43) and President J. Elmer Housley (F '43) reported briefly on current AIEE plans and developments which have been or will be reported appropriately in *ELECTRICAL ENGINEERING*.

3. Report from Dean McKee on Student Branch activities.
Summary of partial reports received from Student Branches, only 8 of the 18 Student Branches in the District having reported, showed a total of 51 meetings of the 8 reporting Student Branches, with an average attendance of 101 per meeting; top attendance reported by Rensselaer Polytechnic Institute branch, with 2,594 for a "House of Magic" show; number of meetings per Branch reporting ranged from 4 to 11 for the year so far.

4. Report on financial status from Worcester District meeting committee.
Situation under control.

5. Preliminary plans for 1948 District meeting.
To be held at New Haven, Conn., under the auspices of the Connecticut Section, April 28–30, 1948.

6. 1949 annual summer general meeting at Swampscott, Mass.
To be held under the direct auspices of the Boston Section June 20–24, 1949, with the North Eastern District participating fully in lieu of any District meetings that year.

7. Organized program for aid to Student Branches.
Action taken to authorize a special committee to collaborate with Student Branches in the District in arranging for industrial speakers to be available for Student Branch meetings. Also, each Section in the District urged to take specific action to maintain helpful liason with Student Branches in its territory; Student Branches urged to reciprocate with appropriate initiative in these matters.

8. Visits to Sections and to Branches by national and District officers.
Covered by action on item 7.

9. AIEE publications to students.
Discussions centered principally on the question of *PROCEEDINGS* distribution. Action was taken to recommend to the AIEE publication committee that the same range of full publication privileges be extended to Student Members as are given to other members.

10. Section representation on Institute committees.
Attention was drawn to the opportunities that individual Sections have to recommend the appointment of especially qualified local Section personnel to serve on the various AIEE national technical and general committees. This is especially important now in view of the impending reorganization and general enlargement of the AIEE technical committees structure.

11. Discussion of geographical subdivision of Sections and Subsections of the District.
Discussions centered principally upon the possibilities for organization and development in Maine and New Hampshire areas.

12. Funds from national headquarters for the support of the District.

13. Prize paper awards.
National, District, and Student Branches.

14. District committee on nominations.
Discussion of F. S. Bacon report.
Objectives described as being "to give a continuity of effort in the planning for and the development of District and national affairs and membership on various national committees." Proposed committee to be constituted of two groups; one group of six representatives to be elected from among the various Sections by the District executive committee to serve 3-year terms, two to be elected each year, this group to constitute the "continuity group"; the second group to be constituted of the contemporary chairmen of each Section and the contemporary District vice-president. The project has been under discussion for some time. Action was taken placing the project in operation immediately, with F. S. Bacon, Jr., of the Boston Section being designated as chairman by Vice-President E. W. Davis.

15. Report of subcommittees for all appointed at Schenectady meeting; co-ordinating; District prize papers; Student Branch prize papers.

16. The discussion of three executive committee meetings per year, date, and place.

Visitors attending the District executive committee meeting included President J. Elmer Housley, Secretary H. H. Henline, and Editor G. R. Henninger.

Measurements and Electronics

Presided over by Professor Truman S. Gray (F '45) of Massachusetts Institute of Technology, Cambridge, and chairman of the AIEE committee on instruments and measurements, the session on measurements and electronics drew an attendance of about 75 persons to audit and discuss four papers.

SELF-BALANCING BRIDGE

"A Self-Balancing Capacitance Bridge" described by A. H. Foley (A '41) of the General Electric Company, Pittsfield, Mass., combines the advantages of the quick indicating capacitance bridge and the precision wide-range capacitance bridge. Features of the new instrument include a high degree of accuracy, a single, greatly expanded scale which represents an improvement of some 3,000 per cent over conventional capacitance meters, and an average balancing time of less than two seconds. The nominal capacitance of a group of units to be tested can be set on an appropriate direct-reading decade dial. After balancing, the main dial indicates the per cent deviation from the normal capacitance. Based upon a simple capacitance bridge network, all adjustments are made in the resistance arm. Bridge unbalanced voltages are sent through a polarized amplifier to a motor which in turn is coupled mechanically to the bridge-balancing resistance. Balance is achieved in accordance with the principles of several mechanisms. The device is considered to be particularly useful in checking large quantities of capacitors for applications where capacitances are critical, as in certain resonant circuits. Close matching of capacitors, to within 1/10 of one per cent, is easily achieved since the scale spread of the deviation dial and the instrument stability are sufficient to permit readings with an accuracy of 0.05 per cent or better.

PHOTOELECTRIC EXPOSURE METER

"A Photoelectric Color Temperature and Exposure Meter" as described by

T. M. McCaw (Student Member) of Worcester (Mass.) Polytechnic Institute, analyzes light on the basis of "color temperature" comparable to the way in which such light affects color-sensitive photographic film. Utilizing two photoelectric tubes in a potentiometer circuit, one adjusted for sensitivity to the blue end of the spectrum and one adjusted for sensitivity to the red end of the spectrum, the device can be used not only for determination of correct exposure under existing light conditions, but to indicate the filter that is required to correct for existing light conditions. For example, Kodachrome is made with a "balance" color sensitivity equivalent to a "color temperature" of about 6,500 degrees Kelvin, and unless correctively filtered, light of a color temperature quality more or less than this figure will produce a photographic effect correspondingly overstrong in the red tone or in the blue tone, respectively.

ELECTRONIC FREQUENCY METER

"A Direct Reading Electronic Frequency Meter for the Audio and Supersonic Ranges" described by H. J. Reich (M '43) and R. L. Ungvary, both of Yale University, New Haven, Conn., utilizing clipper, trigger, and counting circuits to deliver to an indicating microammeter pulses of electric current corresponding in frequency to the peaks of the applied alternating voltage wave, the authors have achieved a direct-reading frequency-indicating instrument having an over-all accuracy of plus or minus two per cent over a frequency range extending from 50 cycles to 150 kc and having a desirable degree of stability and independance of the wave form and signal level of the input voltage.

MEASUREMENT OF ACCELERATION

Walter Ramberg, United States National Bureau of Standards, Washington, D. C., describes "The Measurement of Acceleration with a Vacuum Tube." The special tube for this purpose consists of a fixed cathode and two elastically mounted plates, one on either side of the cathode, used in a circuit comprising a Kelvin double bridge and filter. The elastically mounted plates are subject to displacement in response to acceleration normal to their plane, the displacement affecting the electron current delivered from the cathode to the displaced plate and giving an output current that can be calibrated directly in terms of acceleration. The output at accelerations of 10 g was described as being sufficient to drive a high-frequency recording galvanometer directly without introducing the complications of an amplifier; satisfactory linear indications have been obtained up to approximately 400 g. Principal remaining disadvantages of the tube as presently developed are an unpredictable "zero drift" and a "zero shift" following impacts of very short duration. The device originally was developed for the United States Navy Bureau of Aeronautics for the purpose of obtaining recordings of accelerations on airplanes in flight. Further improvements are contemplated, and other applications are expected to suggest themselves.

Transformer and Capacitor Applications

Four papers pertaining to applications of transformer and capacitors drew an attendance of approximately 50 to a session which was presided over by V. M. Montsinger (F '29) research engineer, power transformer engineering department, General Electric Company, Pittsfield, Mass., and member of AIEE transformer subcommittee.

CURRENT TRANSFORMER TRANSIENTS

"Transient Characteristics of Current Transformer During Faults" were discussed by F. S. Rothe (A '36) and C. Concordia (F '47) both of the central station engineering division, General Electric Company, Schenectady, N. Y. The authors presented data supplementary to a 1942 paper reporting further upon their differential-analyzer studies. Confirming and extending previous findings, the authors reported that when through fault currents are sufficiently large to cause appreciable differential error current to flow, the addition of mutual impedance will reduce the differential current; noting that, in order to reduce the rms 1-cycle error current to 5 per cent of the symmetrical rms value of fault currents, the ratio of mutual resistance to transformer secondary resistance must be of the order of 15 to 1 for short time constants and 25 to 1 for time constants approaching the value of 100 radians. The report also stated that under internal fault conditions, the reduction in differential current from the addition of mutual impedance is not nearly as great as under external fault conditions; consequently, there is a range of conditions over which the addition of mutual impedance will improve appreciably the performance of protective relays served by the current transformers.

TRANSFORMER STANDARDS CRITICIZED

In discussing "Short Circuit Standards for Transformers," A. N. Garin (M '37) of the General Electric Company, Pittsfield, Mass., pointed out that the present AIEE-American Standards Association "Standards for Distribution and Power Transformers (*C-57*, 1943)" is "inadequate and subject to misinterpretation, particularly in the case of line-to-ground faults on Y-connected windings of transformers provided with delta-connected stabilizing windings." Specific and detailed suggestions for revision of the "Standards" were made.

CAPACITORS

Various "Applications of Capacitors for Power Factor Correction" were described by J. S. Williams (A '41) of the Westinghouse Electric Corporation, East Pittsburgh, Pa. Specific applications of "Series Capacitors for Welding Circuits," were described by W. C. Bloomquist (M '45) and R. C. Wilson (A '41) of the industrial engineering department of General Electric Company, Schenectady, N. Y.

Capacitors applied for power factor correction

Cables and Transmission

Approximately 90 persons attended the session on cables and transmission which was presided over by R. M. Pierce (A '37) research engineer, cable works, American Steel and Wire Company, Worcester, Mass.

INSULATION RESISTANCE

In discussing "Insulation Resistance Measurements with Particular Reference to Charging Errors," Doctor E. W. Greenfield (M '37) head of the electrical laboratory for Anaconda Wire and Cable Company at Hastings-on-Hudson, N. Y., pointed out that although perhaps the oldest and simplest of all electrical measurements applied to insulating material was the determination of the resistance of such material to the passage of an electric current, this dielectric measurement presents probably the greatest complexity both in the "doing," and in the interpretation of results. Because the current which flows results generally from the superposition of four more or less independent components, each of different characteristics, the author believes that the traditional "1-minute" insulation resistance measurement requires great care both in performing the tests and in *interpreting* the results. One of the components—charging current—is unrelated to loss-producing current and may introduce a negative error in calculating installation resistance. The author regards this source of error as being appreciable only for high capacitance examples having inherently high insulation resistance connected to a measuring set with a high series calibrating resistance, and discussed corrective equations and curves to permit estimation of the extent of the error for any given test position. With reference to charging currents on long transmission lines (17 miles or more) it was indicated that the correction equation developed for lumped parameters may be applied with little error.

In discussing "Interpretation of Current-Time Curves as Applied to Insulation Testing" R. F. Field (M '40) of the General Radio Company, Cambridge, Mass., demonstrated that charge and discharge current-time curves properly taken can be analyzed rapidly to give three parameters (storage coefficient, relaxation frequency, and maximum indication factor) which define the existing interfacial polarization and a fourth parameter which is proportional to d-c resistivity. Any deterioration occurring in the installation will be indicated by characteristic changes in these four parameters. While the change in a single parameter is sufficient for measuring the determination of simple insulations affected by a single agent, such as moisture, the changes in all four parameters are needed to recognize the effects of several deteriorating agents on the complex insulation of such electric equipment as transformers, generators, and cables. The author comments that the correlation of these changes with dielectric strength will require the accumulation of such data on many units, preferably extending from installation to breakdown.

CABLE SHIELDING

"Semiconducting Shielding—Application and Advantages" were discussed by Victor Siegfried (M '38) chief research engineer, Electrical Cable Works, American Steel and Wire Company, Worcester, Mass. In electric cables, the need for shielding of the individual conductors, or of the finished cable construction has been increasingly apparent over the past 20 years. Improvements in performance and in life under service conditions have been notable in both paper- and rubber-insulated cable, and applications currently being made were reported to indicate also the development of improved varnished-cambric-insulated cable. The use of shielding has contributed directly to cable design improvement effecting better use of materials, reduction of dimensions, and improved service-life expectation. As one typical example, the author described a 15-kv phase-to-phase ungrounded-neutral portable dredge cable which has been in operation for some time. This cable is made up of three number 4/0 259-wire conductors, with 27/64-inch total insulation including semiconducting rubber layers over and under the insulating rubber, and semiconducting fabric tape over each conductor. The three conductors are laid up with three number 2 133-wire ground strands and jute fillers in the valleys of the cable core. The external covering consists of tape and a jacket of reinforced, synthetic rubber tapes with tape, a jute serving, and a special armor overall, giving a group outside diameter of 4.2 inches. It is interesting to note in this connection that the standard Insulated Power Cable Engineer' Association rubber-insulation thicknesses for this voltage rating is 27/64 inch, so that in this construction the effective insulation was reduced to about 23/64 inch because of the semiconducting internal and external shielding used on the individual conductors. On an accelerated voltage-life test, this cable stood up without failure under 32 kv to ground for 21 days, 40 kv for 10 days, 45 kv for 10 days, 50 kv for 12 days, 55 kv for 10 days, and 60 kv for 5 days. Other short-time voltage breakdown tests showed values in excess of 100 kv to ground. The author expressed firm belief that these remarkable values were the result of the proper employment of semiconducting shielding.

TRANSMISSION MODERNIZATION

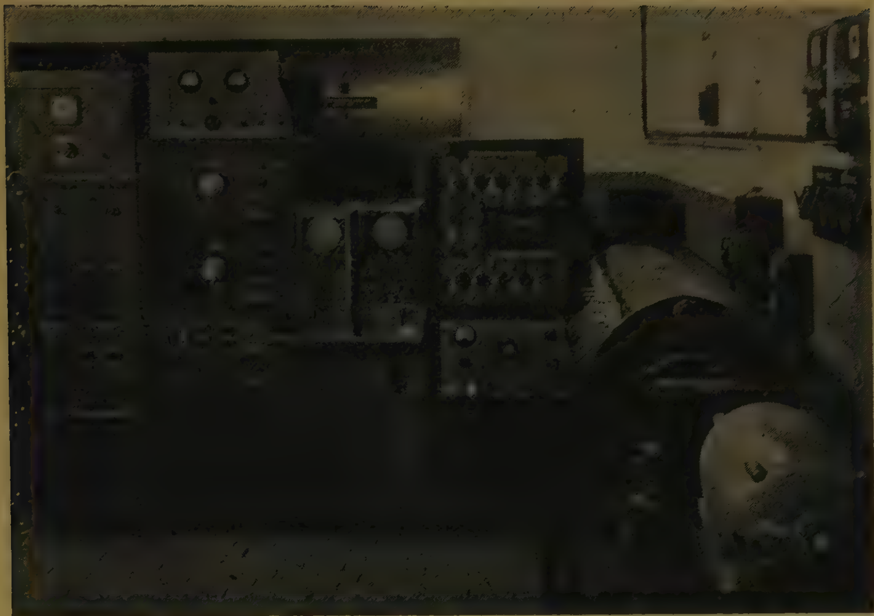
"Experience with Modernization of Transmission Lines on New England Power Association System" was described as H. R. Stewart (M '39) protection engineer for the New England Power Service Company, Boston, Mass. The general objective in the rehabilitation of older lines was described as being the reduction of lightning flashovers, double circuit outages on double circuit lines, conductor burn downs, and, on the lower voltage lines, the reduction of squirrel and bird troubles as well as lightning flash-overs. On 66-kv and 110-kv wood pole lines having no overhead ground wire, but having grounded steel crossarms, the impulse insulation to ground was improved by disconnecting the grounding lead from the crossarms and inserting wooden insulators in the guy lines, and by providing appropriate gap in the grounding downlead. The factor used for downlead gap and for the length of the wood strain insulator was approximately two feet of wood for each disk used in the normal insulator strings, with protective horn gaps on the strain insulators set at half the wood length. On a 66-kv wood pole line having an overhead ground wire, steel wishbone crossarms were replaced by a single pole-top wood crossarm braced to the pole by angle iron braces one of which was extended upward and outward above the crossarm to carry the ground wire, the downlead being brought in seven feet or more down the pole, practically doubling the effective insulation.

Servomechanisms

"Closed-cycle control systems" as a more appropriate and accurately descriptive name to succeed the currently used "servomechanisms" was proposed ardently by G. S. Brown (A '33) associate professor of electrical engineering, Massachusetts Institute of Technology, Cambridge, who presided at a session devoted to this subject matter. The three papers presented and generously discussed drew an attendance of about 70. The term "servomechanism" was described as having been popularized for more or less indiscriminate use under wartime conditions of a rapid development and diverse application to describe a control system variously otherwise known as "positional control system," "closed-cycle automatic control system," "closed-cycle dynamical system," and "closed-cycle control system." General use of the latter was recommended.

AERIAL PHOTOGRAPHY

The relatively belated applications of "Servomechanisms in Aerial Photography" were described by Doctor Roy C. Gunter, Jr., assistant director of the optical research laboratory of Boston (Mass.) University and assistant professor of physics at Clark University, Worcester, Mass. Doctor Gunter described the application of a gyroscope control system to stabilize an aerial camera mount to remove the very low-frequency vibration representing the pitch and roll of the aircraft. He also described further refinement through the use of photoelectric tubes and a potentiometer-type system designed to detect and correct for other vibrations inherent in an operating aircraft that are detrimental to the full realization of the precision capabilities of a modern aerial camera. Especially bothersome vibrations have been detected and grouped around 40 cycles per second, and another group around 800 cycles per second. Automatic focusing and other desirable controls of



Voltage regulator analogy equipment

aerial camera installations were described as readily and practically attainable with closed-cycle control systems. As representing the trend toward larger cameras, the author reported that a 100-inch focal length camera weighing 625 pounds has just been completed and a 240-inch focal length camera is in the design stage currently at Boston University. The author emphasized his belief that to obtain the desired high resolving powers and to obtain an over-all high degree of performance, comparable with the potentialities of a modern aerial camera, "more and more electronic and servomechanism control systems will be necessary."

TWO-PHASE MOTORS

The development and application of "Two-Phase Induction Motors for Instrument Servomechanisms," were described by J. E. Ward of Massachusetts Institute of Technology, Cambridge. The author pointed out that the 2-phase induction motor is a simple, reliable piece of electric equipment; that it has no rotor windings to burn out, no commutator or brushes to maintain; that it can be designed and built with characteristics highly desirable for servomechanism application; that it can be driven easily from an a-c amplifier in the same manner as a loudspeaker, although its inefficiency and high heating in a servomechanism limits its application to small power ratings. Specific attention was given to power outputs of approximately five watts or less, although design factors presented were stated to be adequate for outputs of up to 100 watts. He quoted as a desirable trend in the design of two-phase control motors a greater number of poles, higher operating frequencies, and greater accelerations; also that the use of integral drag-cup tachometers is desirable, and such are now available.

VOLTAGE REGULATOR ANALOGY

A discussion of the "Solution of the General Voltage Regulator Problem by Electrical Analogy," was given by E. L. Harder (M '41) of the Westinghouse Electric Corporation, East Pittsburgh, Pa. The transient performance of a generator voltage regulating system is the terminal voltage, as a function of time, following a voltage disturbance, or following the sudden addition of load. The general quantitative solution to this problem through the use of the servomechanism-analyzer method was described, and results given for linear systems in terms of the parameters of the system. The servomechanism-analyzer was described as having demonstrated its value in providing essential oscillographic data which could not have been secured economically in any other way, and in checking and supplementing calculated damping curves. Thus proved for the simple 3-delay system, the author considers that the servomechanism-analyzer method opens the way for obtaining general data on more complicated systems which could not be calculated; that even for the 3-delay system, it affords the only practical way of including initial conditions in a general study. The greatest value of the servomechanism-analyzer for voltage regulation studies is visualized as being in the analysis of the more complicated systems which cannot be calculated economically; these including the various regulating combinations and less-simple exciters with coupled field circuits, and feed-back for sustaining fields, and with the inclusion of saturation effects. The author believes that such studies should lead to improvements in designs, and also to facility in the determination of the best systems which may be designed to meet any given requirements.

Communications

Four papers on various communication topics drew an attendance of approximately 40 to a session presided over by B. K. Northrop (M '43) associate professor of electrical engineering, Cornell University, Ithaca, N. Y.

CABLE CARRIER SYSTEM

"An Improved Cable Carrier System" by H. S. Black (F '41), F. A. Brooks (A '36), A. J. Wier (A '36), and I. G. Wilson of the Bell Telephone Laboratories, Inc., New York, N. Y. described the new 12-channel cable-carrier system which has been developed by the Bell system to a point where it is suitable for transcontinental communication. With the system, 12 1-way messages are transmitted simultaneously over a single 19-gauge cable pair. Two-way communication is afforded by the use of separate cables for each direction of transmission. By using a pair of such cables as a transmission system, as many as 100 2-way 12-channel systems can be operated in the two cables. Important features of the newest development are negative feed-back amplifiers of improved design, new arrangements for accurate equalization of the cable loss, and automatic "thermistor" regulators which continuously control the transmission of each system. Known as the *K2* system, this newest development accounts for some 2,500,000 2-way message-circuit-miles installed during the past three years; this in addition to another 2,500,000 miles of long distance message circuits in the immediate predecessor system known as *K1* which was announced in 1938.

Three portable test sets especially developed for this new improved cable carrier telephone system were described in a paper under the title "New Test Equipment and Testing Methods for Cable Carrier Systems" presented by W. H. Tidd (A '31), S. Rosen, and H. A. Wenk of the Bell Telephone Laboratories, Inc., New York, N. Y. One of these is a tube test set, one a decade oscillator for frequencies of 2–79 kc, and the third a high-sensitivity selective transmission measuring set covering the range from 10–150 kc.

TELEMETERING

"Carrier-Current Telemetering Within the New England Power System" was described by L. G. Eaton of the New England Power Service Company, Boston, Mass. The systems described apply essentially to the telemetering of the power delivered over tie lines between the New England Power Service Company, the New York Power and Light System, and the Connecticut Valley Power Exchange. Continuously increasing power requirements, which will call for use of the full capacity of all available supply facilities in the area, with but narrow tolerance for outages, made the system necessary. Prior to the installation of the radio telemetering system, close control of the deviations from transmission schedules over these

various tie lines was almost impossible because of the time required for telephone interchange of information and instructions between the various dispatchers and station operators. The system provides for continuous indicated readings on the several key interchange lines at two widely separated dispatchers' offices and at a key switching station, and provides also a direct radio telephone communication channel between the two dispatching offices.

B. E. Lenehan (A '24) of the meter division, Westinghouse Electric Corporation, Newark, N. J., described "A New Single Side-Band Carrier System for Power Lines," involving the frequency-addition principle, for a communication circuit. Power line communication differs from other carrier signalling in that it uses a channel designed primarily for quite a different service and one carrying heavy power currents at very high voltage, which means that any impedances added to alter the characteristics will be of large physical size and correspondingly high cost. Equipment to be used on such lines must be continuously adjustable in frequency, which is the basis on which this system was developed. Apparatus used in Mr. Lenehan's system consists of linear modulators combined with wide-range phase-splitting circuits to produce the signals. The general use of single-side-band communication transmission is equivalent to almost doubling the available frequency space, and offers additional advantages in noise reduction by greater equivalent power output.

Transportation

The attendance drawn by the three formal papers presented at the transportation sessions was only about 30, but extended discussion took up an entire afternoon. H. F. Brown (M '25) assistant electrical engineer, New York, New Haven, and Hartford Railroad, and chairman of the AIEE Connecticut Section presided.

DIESEL ELECTRIC LOCOMOTIVE

"Recent Developments in Diesel-Electric Locomotives" were reviewed by E. K. Bloss (M '28) supervisor of Diesel maintenance and operation, mechanical department, Boston and Maine Railroad, Boston, Mass. Mr. Bloss quite comprehensively reviewed both the history and the present trend in development and application of Diesel-electric power.

The gas-electric rail motorcar was a post-World War I development. In the United States, Diesel-electric locomotives followed closely on the heel of these cars. When first put into United States service in 1925, Diesel locomotives were utilized primarily to eliminate smoke nuisance, and about the only requirement laid down for the electrical engineer was that the generator should not overload the engine. Consequently, the differential series field was used in spite of the fact that a generator so equipped could absorb full engine horsepower at only one current value. As these locomotives began to be used for main line trains in 1933–1934, it became highly desirable to get a better utilization of engine horsepower over a wider range of speed and tractive efforts, which means simply a wider range of full utilization of engine power expressed in amperes and volts on the main traction generator. Development of the split pole exciter resulted, in which the differential series field was wound around only a portion of the field pole so that this portion became saturated and resulted in an over-all generator performance capable of utilizing full engine horsepower over approximately half of the allowable current and voltage range of the generator. Contemporary attempts to use straight shunt-wound exciters having rheostat field control operated by the engine governor proved to be overcomplicated until about 1939 when the idea was accelerated through the incorporation of servomechanism control. These developments provided utilization of full engine horsepower over about 70 per cent of the current range of the generator but had the disadvantage of being based upon full engine speed and offering no suitable control of engine output at reduced speed. The continuing drive to secure greater horsepower for less weight and space in Diesel-electric locomotives has led to the latest type of control, the amplidyne control. This control system enables maximum utilization of engine power from the limit of commutator voltage at one extremity to the limit of current-carrying capacity at the other extremity; further provides sensitive response to the varying tractive requirements placed upon the locomotive and provides any desirable reduction of torque at any of the selected engine speeds. The question now is whether the modern Diesel electric locomotive with its a-c generators, d-c generators, rectifiers, relays, saturated reactors, servomechanisms, magnetic clutches, thermostats, and other similar devices has a control system so complicated as to be impossible of satisfactory maintenance on the average railroad.

RADIO COMMUNICATION

In discussing "Radio Communications in Railroad Service," L. J. Prendergast of the Baltimore and Ohio Railroad presented a brief history of railroad signalling developments from the pretelegraph "time-table basis" of main line train operation down to the modern automatic block signal and on into the realm of radio communications as applied to main line train operation, end-to-end communications on mile-long freight trains, and the dispensing requirements of a modern freight transportation yard. Mr. Bloss reported that by relatively recent action of the Federal Communications Commission, the railroads have been allocated 60 clear channels in the 152–162 megacycle range and some additional channels which must be shared with television requirements. As represented railroad communication requirements, for which it is hoped that dependable and economical radio equipment may be developed, include the following: communication between the control center and the many locomotives normally at work at one time in a large yard, also between the conductor and the locomotive engineer working on the classification hump; from the area control center to each of the industrial switching and pickup locomotives scattered on daily assignments through many urban industrial areas; walkie-talkie equipment for use by maintenance-of-way crews, Army walkie-talkie equipment being regarded as too expensive to maintain and operate to be practical for this service. Mr. Prendergast stated that there are about 700 radio station installations in the United States in the Railroad Radio Service representing about 35 railroads.

PASSENGER CAR PROBLEMS

"Electrical Problems on Railroad Passenger Cars" were described by H. H. Hanft, transportation engineer, Westinghouse Electric Corporation, East Pittsburgh, Pa. From the day of the first application of electric power to a railroad passenger car, about 1905, the connected load per car has grown from about 600 watts (20 amperes, 30 volts) to some 20 kw in passenger cars currently being built, with more than half the load being air-conditioning equipment. On a modern 18-car passenger train, the locomotive must contribute more than 750 horsepower to operate the axle-driven electric generators on the individual cars. Several operating experiments have been conducted during recent years wherein the source of electric power for individual cars came from a single large power plant at the head end of the train. In spite of its more obvious advantages, however, this system has not found favor from the standpoint of practical operation which favors the use of cars each equipped to be a self-sufficient unit. Individual installations avoid difficulties and limitations otherwise encountered in the universal practice of shifting cars from train to train and even from road to road.

Industrial Application

Six papers dealing with miscellaneous applications of electric equipment drew an attendance of some 95 persons to a session presided over by V. F. P. Sepavich (A '37) supervisor of engineering research and development, Compton and Knowles Loom Works, Worcester, Mass.

WIRE INDUSTRY

In describing "Electrical Applications in the Wire Industry," J. G. Roby of the industrial engineering division of the General Electric Company, Schenectady, N. Y., devoted most of his attention to the various machines and controls associated directly with the actual drawing of wire. Basically, a wire drawing machine consists of a die equipped with facilities for supplying lubricants to the rod before it enters the die, and a power-driven drum which acts as a capstan to draw the wire through the

die. A complete wire drawing machine may consist of several dies operating in a series with their related capstans, the number being dependent in part upon the number of passes through which the wire can be put before annealing. Close control of relative speed, tensions, and other factors are essential. For about the past thousand years or so, wire has been manufactured by fundamentally the same processes, but the progress of the art was slow until relatively recent years, when the evergrowing use of electricity in the industry enabled important improvements to be made in both speed and quality of wire drawn. As to the future, the industry is looking hopefully to the development of electric drive and control equipment or what is known as "reactive wire drawing." "Reactive wire drawing" is descriptive of the method of drawing wire wherein a back tension of as much as approximately 50 per cent of the die pull is placed on the rod in its approach run to the die. Die heating is one of the limitations on the speed of wire drawing, and because elongation of the bar prior to its entry into the die results from back tension, it materially reduces the reduction work required of the die and proportionally reduces the heating of the die. Thus, says Mr. Roby, the next step for the electrical industry is to work with the machine manufacturer to determine a suitable means of regulating this back tension. This probably will mean a machine of the multiple, individually motorized block-type but with much greater refinement of control than is in use at present.

ELECTRIC REEL TENSION

Various devices and combinations of equipment for obtaining "Electrically Controlled Tension of Reeling Operations" were described by R. M. Scott, sales manager, New England Butt Company, Providence, R. I. In the spooling or reeling of any material, whether that material be wire, a textile fiber, or a fabricated material in strip form, certain operating conditions must be adhered to if a good package is to be obtained. A "good package" is wound with a constant tension from beginning to end; each layer is wound with sufficient tension to cause the material to wrap tightly around the barrel, but not so tightly that the material will pull down into the next layer; and traverse is even without crossover or gap. A constant speed traverse motion is essential to prevent the material from piling up on the ends because of slow reversal of the traverse, and to prevent piling up in the center of the reel as a result of too fast reversal of the traverse. Mechanical friction types of tension controlled devices leave much to be desired and are being superseded rapidly by various electric, electronic, and combination electric devices. Electronics is not new to the wire industry, because thyraton-controlled devices on wire drawing machines and on take-up stands have been in use since about 1930. The development and improvement of electronic and other control devices incidental to the pressure of World War II have resulted in noteworthy improvements in electric equipment for the accurate and wholly automatic control of tension in a host of reeling operations.

TEXTILE INDUSTRY

One of the supposed most complete approaches to an all-electric machine ever attempted in the textile industry was reported in a paper describing "Electric Equipment for Two-for-One Twister" (*EE, May '47, pp 474–6*) by E. C. Gwaltney and H. J. Burnham of the Saco-Lowell Shops, Biddeford, Maine. All textile fiber, whether natural or synthetic, must be twisted into yarn before it can be woven into fabric. The possibilities of revolving the yarn being twisted around a stationary supply package and obtaining two turns of twist for every revolution of the spindle have been known for years but, because of the complexities involved, have not heretofore been applied successfully commercially except to a limited extent in Germany. By putting in two turns of twist for every revolution of the spindle, the linear speed of the yarn delivered is doubled, and consequently the production per spindle is doubled correspondingly without increasing spindle speed. It is expected that two-for-one twisters eventually will replace all forms of twisters except on those yarns requiring an extremely low twist, and that electrification of spindles on the present machine will point the way to future electrification in the textile industry in which, in the United States alone there are more than 10,000,000 spindles twisting the type of yarn to which the present two-for-one twister is suited.

"Electric Drives for Textile Finishing Ranges," (*EE, Mar '47, p 287*) were described by R. B. Moore (A '45) of the General Electric Company, Schenectady, N. Y. and H. C. Uhl, (M '40) of the General Electric Company, Atlanta, Ga. In the processing of textiles, the trend in recent years has been away from "batch" and toward "continuous" processing. In the batch system, each lot of cloth is put through various separately operated processing machines and rolled or folded after each operation before being transported to the next machine for the next processing. In the continuous system, each lot of cloth is passed continuously and without intermediate handling through a line-up of machines which in the textile industry is called a "range." This continuous process with machines operated in tandem requires carefully co-ordinated adjustable-speed machine drive, in which the electric drive is assuming a predominant position. "Electric range drive" is defined as one in which co-ordination is effected by adjustment of the speeds of the individual range motors, as distinguished from "mechanical" range drive, which is defined as one in which co-ordination is effected entirely by adjustment of the mechanical ratios between the drives and the individual range units. The authors presented basic requirements of range drives, basic considerations in selecting drive equipment, a comparison of electric and mechanical drives, a description of various types of electric drives and co-ordination control, and specific recommendations for selecting proper equipment for specific conditions.

MOTORS

"Metallic Rectifiers as a Power Supply for Adjustable-Speed Motors" were discussed by F. L. Reed (A '42) engineer, motor division, Westinghouse Electric Corporation, Buffalo, N. Y. Mr. Reed reported that on the basis of several years of laboratory tests coupled with 18 months of actual operating experience in the Buffalo plant, rectifiers cost less than motor-generator sets for motors of from 1 to 15 horsepower. He reported further that the efficiency is higher, regulation is essentially the same, commutation is not adversely affected, mounting is not much of a problem, and maintenance is simplified.

In discussing "D-C Braking for A-C Induction Motors," F. D. Snyder (A '45) of the Westinghouse Electric Corporation, Boston, Mass., dealt principally with textile applications although the same principles and similar equipments are used for other industrial drives. This is a comparatively recently developed method of obtaining controlled stopping of electric motor driven equipment. The source of direct current may be from a separate bus or, more commonly, through the use of a rectifier built in as an integral part of a motor control cabinet and utilizing a common source of a-c supply. Test curves which were run on a 5-horsepower 1,750-rpm 220-volt 3-phase squirrel-cage motor reveal the following: as an a-c motor, the normal full-load current is about 12 amperes and the full-load took approximately 15 pounds at 1 foot radius on the motor shaft; with 20 amperes direct current put through the motor winding, using any two of the three terminals, full-load braking torque is developed instantly at the normal operating speed of 1,750 rpm; this braking torque increases to approximately 50 pounds at 1 foot radius and 200 rpm, about three times the full-load torque; from that maximum, braking torque drops off and motor speed drops to zero, but continued application of direct current provides a holding torque at standstill. The author reported application on motors ranging in size from 1/4 to 200 horsepower, single phase and polyphase.

Applications to Machine Tools

Except for the student sessions, the record for attendance at Worcester technical sessions went to this one with approximately 125 persons in attendance. The session was presided over by D. R. Percival (A '44) electrical engineer, Norton Company, Worcester, Mass.

TOOL BUILDERS STANDARDS

In describing "Machine Tool Electrification as Influenced by the National

Machine Tool Builders Electrical Standards," A. L. Krause of Brown and Sharpe Manufacturing Company, Providence, R. I., presented a brief history of the development of electrified machine tools. He traced the evolution in electrification from the time when electrification consisted of a shop owner having the electrician "connect" an electric motor for a machine tool as a power source in lieu of some other source, down through the emergency wartime standards to the recent postwar standards which provide a basis for a desirable degree of uniformity in the location and arrangement of electric drive and associated control equipment on machine tools.

FREQUENCY CONTROL

The "Application of High-Frequency Electric Equipment to Machine Tools," was described in some detail by F. H. Penney of the General Electric Company, Schenectady, N. Y.

As a means of overcoming one of the principal limitations otherwise imposed on the use of squirrel cage induction motors, G. W. Heumann (M '46) of the General Electric Company, Schenectady, N. Y., discussed "Adjustable Frequency Control of High-Speed Induction Motors." The simplest type of electric motor available to industry is the hard working squirrel-cage induction motor. However, its normal operating speed usually is controlled by two predetermined factors, one in original design basis and the other the operating frequency of the power system to which it is attached for operation. On a commercial 60-cycle power system, the highest speed attainable is 3,600 rpm, which is the synchronous speed of a 2-pole motor.

Higher speeds could be obtained if the frequency were raised above 60 cycles, and the only limitation would be the design of the motors and the power supply systems. Thus, the provision of an adjustable frequency system would enable squirrel-cage induction motors to operate as adjustable speed motors over a wide range of speed and in excess of 3,600 rpm. The author reviewed various systems as have been developed to date to meet requirements of the aviation industry, including electronic and other types of frequency conversion equipment. The belief was expressed that, as time goes on, such equipment will find application in other industrial fields where high and adjustable speeds are desired and where squirrel-cage induction motors offer advantages over other types of driving motors.

MOTORS

"Magnetic Vibration in Motors" was discussed in some detail by R. C. Griffith (A '35) and B. F. Hammarstrom (A '35) of the Heald Machine Company, Worcester, Mass.

In discussing "Electronic Feed Drives for Milling Machines" Mark Morgan, electrical engineer, Reed-Prentice Corporation, Worcester, Mass., concerned himself primarily with some of the problems encountered in the selection and application of electronic types of variable-speed drives to machine tools. He reported that, on the basis of experience and experiments, the general use of field control in a feed drive is not a desirable practice. In discussing duplicators on a standard milling machine, with an exceedingly wide range of speed requirements and necessary high degree of accuracy, the electronic type of drive motor control was considered to be highly advantageous. Minimum speed, rather than maximum speed, seems to constitute the principal problem with this type of equipment; thyratron control circuits make it impractical to go lower than 20 rpm, other types of controls having minimum speeds as high as 80 rpm. As to heat dissipation, gas-filled tubes were reported as preferable to mercury vapor tubes; also, half-wave units were reported as preferable to full-wave or 3-phase units of identical rating.

CONTROLS AND DRIVES

S. I. Rice of the Heald Machine Company, Worcester, Mass., described in some detail the photoelectric and other electronic types of safety and operating control equipment as applied to boring machines performing repetitive operations of extremely high precision requirements, such as the boring of intake and exhaust valve stem bushings in airplane cylinders as an example.

Student Technical Sessions

With an attendance totaling more than 250, two technical sessions were given over entirely to student presentations. At session *A*, under the chairmanship of Kenneth H. Truesdell of Worcester (Mass.) Polytechnic Institute, the following six student technical papers were presented:

"A Circuit Breaker for General Household Use" by John Hambor, Worcester Polytechnic Institute.

"An Electric Knockmeter for Internal Combustion Engines" by Richard W. Husher, Yale University, New Haven, Conn.

"A New Type of Phase Sequence Indicator" by James Feltner, University of Connecticut, Storrs.

"A Method of Computing Voltage Regulation for Synchronous Alternators" by Laverne R. Anderson and Charles H. Stanford, Cornell University, Ithaca, N. Y.

"Engineering Trends" by Eugene E. Hand, Rhode Island State College, Kingston.

"The Application of Circle Loci in the Solution of Electrical Problems" by Warren J. Dornhoefer and Gordon C. Bill (graduates), Yale University.

At session *B*, under the chairmanship of Douglas L. Liston of the University of Vermont, Burlington, the following seven student technical papers were presented:

"A Simplified Resistance-Tuned Oscillator and Multivibrator" by Ralph Carlson, University of Connecticut.

"Electronic Fractional Horsepower Torque Measuring Indicators" by R. O. Williams, Northeastern University, Boston, Mass.

"The Electronic Buoy" by K. R. Burkdadrt, H. J. Kenerleber, J. F. McDonough, and A. H. Galipeair, Rhode Island State College.

"Theory and Application of a Complex Vacuum Tube Voltmeter" by F. H. Stansfield, Northeastern University.

"The Electrostatic Air Filter" by Herbert Greeley, David Ward, and Richard Walder, Rhode Island State College.

"The Design of a Laboratory Electronic Phase-Shift Circuit" by F. H. Zimmerli and P. E. Smith, Rensselaer Polytechnic Institute, Troy, N. Y.

"A Compact 45-Kv Surge Generator" by Martin J. Riley (graduate), Worcester Polytechnic Institute.

PRIZE WINNERS

At a combined general session following the two parallel student technical sessions, Dean E. R. McKee (M '36) of the University of Vermont, Burlington, chairman of the Northeastern District committee on student activities announced the winners as follows, and presented the district prizes accordingly:

For Session *A:*

FIRST PRIZE: James Feltner of the University of Connecticut.

SECOND PRIZE: Richard W. Husher of Yale University.

THIRD PRIZE: John Hambor of Worcester Polytechnic Institute.

For Session *B:*

FIRST PRIZE: Martin J. Riley (graduate student of Worcester Polytechnic Institute).

SECOND PRIZE: R. O. Williams of Northeastern University.

THIRD PRIZE: Ralph Carlson of the University of Connecticut.

PRESIDENT HOUSLEY'S SPEECH

AIEE President, J. Elmer Housley (F '43) addressed the joint students group, giving a general résumé of current AIEE activities, especially those represented by the studies recently made by the subcommittees of the AIEE planning and co-ordination committee pertaining to developments of the technical and professional activities of the Institute. Mr. Housley spoke also at some length on the current studies and activities pertaining to the position of engineers under existing and impending labor legislation. These activities have been reported in detail on pages 594–5 of *ELECTRICAL ENGINEERING.*

AIEE Vice-President E. W. Davis (F '34) of the North Eastern District, also gave the assembled students a rousing challenge to avail themselves of the widespread opportunity for development and application of electric equipment, pointing out that the magnitude, scope, and variety of opportunities, and needs for the development and application of all kinds of electric equipment is actually greater now than at any previous time; also, that these opportunities challenge the initiative, imagination, and perseverance of the individual with very worth-while physical and spiritual rewards at stake.

SECTION • • • • • •

Cleveland Section Host for NACA Inspection Trip

Members of the Akron, Canton, and Mansfield Sections were invited by the Cleveland Section to an inspection trip at the National Advisory Committee on Aeronautics Aircraft Engine Research Laboratory at the Cleveland Airport on April 18, 1947.

Research facilities in the field of aircraft propulsion, for which the laboratory is famous, were shown to the visitors. Particular emphasis was given to the electrical background for these facilities. A very pleasant $2^1/_2$ hours were spent on this tour.

The members then were entertained at a dinner at the Methodist Children's Home in Berea, after which A. H. Heidenreich, electrical consultant for the NACA, spoke on "Wind Tunnel Drives."

New York Section Adds Hudson Valley Division

On the evening of April 15, 1947, the Hudson Valley division of the AIEE New York Section was organized at Poughkeepsie, N. Y. The following officers were elected to take office immediately and to serve until May 31, 1948: H. A. McLaughlin (M '30) chairman, D. B. McGuire (M '43) vice-chairman, T. F. X. Vail (A '46) secretary, and W. E. Smalley (A '29) treasurer.

Chairman J. H. Pilkington (M '34) of the New York Section spoke on New York Section activities and on some interesting developments in the power field. Considerable interest was shown in the venture by the 30 men who attended the meeting. Divisions of the New York Section now total three with the New Jersey, Mayaguez, P. R., and Hudson Valley Divisions.

Transformer Talks Presented to South West District Groups

P. L. Bellaschi (F '40) of Westinghouse Electric Corporation, Sharon, Pa., gave a series of talks on power transformer insulation and protection, covering major developments in America since 1939, to AIEE groups in Little Rock, Ark.; Memphis, Tenn.; St. Louis and Kansas City, Mo.; Wichita, Kans.; Oklahoma City and Tulsa, Okla.; and Dallas, Houston, and Beaumont, Tex.; during the period April 14–25, 1947.

STANDARDS • • •

Aircraft Machine Test Code Released

"Proposed Test Code for Direct Current Aircraft Machines (AIEE *800*)" was published by the AIEE Standards committee in March 1947 for one year trial use after preparation by the subcommittee on aircraft electric rotating machinery of the AIEE committee on air transportation. Chairman of the group is M. L. Schmidt (M '43) of General Electric Company, Fort Wayne, Ind. It is the purpose of the code to define uniform acceptable methods of making tests to determine that the performance and other characteristics of d-c machines for aircraft comply with specification and application requirements.

Included in the code pamphlet are characteristics of electric power supply for testing, insulation resistance, dielectric tests, winding resistance measurement, field coil check, determination of electrical neutral, magnetic saturation tests, input-output tests, commutation, radio interference, generator performance characteristics, motor speed-torque characteristics, temperature test, altitude tests, overspeed tests, self-induced vibration, transient characteristics, and life tests.

ABSTRACTS • • • •

prepared by the authors of the papers and approved by the technical program committee.

TECHNICAL PAPERS previewed in this section will be presented at the AIEE summer general meeting, Montreal, Quebec, Canada, June 9–13, 1947, and will be distributed in advance pamphlet form as soon as they become available. Members may obtain copies by mail from the AIEE order department, 33 West 39th Street, New York 18, N. Y., at prices indicated with the abstracts; or at five cents less per copy if purchased at AIEE headquarters or at the meeting registration desk. Prices of copies to nonmembers will be twice those for members, less five cents for mailed copies.

Mail orders will be filled AS PAMPHLETS BECOME AVAILABLE

Communication

47-121—TVA Co-ordinated Communication System; *T. DeWitt Talmage (M '40). 30 cents.* This paper describes communication and control systems used by the Tennessee Valley Authority, principally to expedite the operation of its multiple-purpose dams, electric power generating stations, transmission lines, and substations. Seventy per cent of the 10,000-mile communication and control system is obtained by carrier channels superimposed upon power lines. This paper explains relationships which exist between carrier channels that are utilized for pilot relay, remote trip, telemeter, automatic load-frequency control, and telephone purposes. Close engineering co-ordination of 45 telephone switchboards, including 13 of the automatic type, and a variety of kinds of telephone circuits, totaling over 6,000 miles in length, permits the rapid handling of 2,500,000 telephone calls each year. The basic equipment used in establishing these circuits and their flexible interconnecting arrangements is standardized and the units are applicable to systems of any size.

47-131—Pulse Code Modulation; *H. S. Black (F '41), J. O. Edson. 20 cents.* A radically new modulation technique for multichannel telephony has been developed which involves the conversion of speech waves into coded pulses. An 8-channel system embodying these principles was produced, and illustrations are given of its transmission performance. The method appears to have exceptional possibilities from the standpoint of freedom from interference, but its full significance in connection with future radio and wire transmission may take some time to reveal.

47-140-ACO—Radio Interference Suppression in Canada, *H. O. Merriman. 20 cents.* (No abstract furnished.)

47-146—An Electronic Regenerative Repeater for Teletypewriter Signals; *R. B. Hearn. 25 cents.* When the start pulse of a start-stop teletypewriter signal is received by the repeater an oscillator circuit is activated. The received signals then lose control of the oscillator for the duration of the remaining pulses in a signal representing one teletypewriter character. A short impulse produced by the oscillator after a delay of half a pulse length and repeated at intervals one pulse length apart causes signals to be retransmitted by the repeater in agreement with the signal being received at the instant of the impulse. Distorted pulses received are thus restored to their proper length when retransmitted.

47-150—Modulation in Communication; *F. A. Cowan (F '45). 20 cents.* To meet a variety of communications needs many systems of modulation have been developed and papers describing them are available in the technical literature. Some of the earlier methods of explaining modulation have acquired a classical textbook status. Recent trends have placed emphasis on modulation systems which may be more readily understood when viewed in a somewhat different manner. This paper presents certain conceptions which may facilitate a better understanding of the various systems of modulation and the relationships between them.

47-152—Distortion in a Pulse-Count Modulation System; *A. G. Clavier, P. F. Panter, D. D. Grieg (A '39). 40 cents.* In the further development of pulse time multiplex systems the form of modulation known as pulse count modulation has been studied both theoretically and experimentally. This paper reviews briefly the principles of pulse communication and its extension to pulse count modulation (PCM). Unlike the conventional types of modulation, PCM is represented by a discrete scanning of the amplitude of the modulating signal rather than a continuous amplitude scanning, in addition to the discrete scanning in time, which is common to the other forms of pulse modulation. The discrete nature of such a system introduces a type of distortion which is a function of the number of amplitude

levels used. The relation between the number of levels and this type of distortion has been investigated and is discussed. Several types of signals are analyzed mathematically; namely, a single frequency, a 2-frequency signal, and finally a continuous band of frequencies. In connection with the multifrequency case, the application of the Fourier transform to pulse amplitude modulation and its extension to PCM is introduced. In addition, the cross talk introduced in different channels of the modulating frequency is shown graphically for several amplitude levels.

47-160—An FM Telegraph Terminal Without Relays; *F. H. Cusack, A. E. Michon (M '47). 25 cents.* The domestic telegraph system is engaged in a vast expansion of its carrier telegraph plant. In this connection new equipment has been designed to supply the need for a simplified, compact, and efficient frequency-modulated carrier terminal for use at teleprinter and relatively slow multiplex speeds. Relays for transmitting and receiving have been eliminated entirely and in their place electronic devices have been used. The carrier terminals are furnished in nine different frequencies. Two groups or a total of 18 channels can be operated over a voice frequency band approximately 3,000 cycles wide. This paper describes the transmission and receiving circuits in detail and explains the operation of the d-c leg circuits. Over-all performance data are included. Satisfactory operating ranges have been demonstrated over a 6,500-mile circuit consisting of nine successive carrier sections connected in tandem to form an entirely electronic system.

47-166—Distortion and Band Width Characteristics of Pulse Modulation; *H. L. Krauss (A '42), P. F. Ordung (A '43). 25 cents.* Various types of pulse-amplitude and pulse-time modulated waves have been analyzed by a novel method to determine their exact frequency spectra. Using these results the inherent distortion produced when the audio signal is recovered with a low-pass filter is calculated. The minimum allowable ratio of pulse repetition frequency to maximum audio frequency is expressed in terms of the distortion and the percentage modulation. The form of the result is shown to be common to all types of pulse time modulation. The effects of pulse width, pulse shape, and percentage modulation on the required band width are also discussed.

47-171—The Application of Heterodyne Modulation to Wide-Band Frequency-Modulated Television Relays; *Wilson P. Boothroyd. 20 cents.* Several methods for accomplishing heterodyne modulation are discussed together with design comments on a television relay system which employs heterodyne modulation to obtain a frequency-modulated 1,350-megacycle carrier.

Electric Machinery

47-113—Dynamic Brush Characteristics by the Dynamotor Method; *C. J. Herman (A '44). 25 cents.* The application of carbon brushes to electric machines generally involves a long process of trial and error. Design and manufacturing variables in the machines combine with the relatively unknown performance characteristics of the brushes themselves to create most of the complex problems of brush application. To improve the accuracy and speed of brush application engineering as needed during the World War II, a dynamotor test method was developed to measure accurately friction and contact drop versus brush face temperatures over wide ranges of operating conditions. Over three years' usage of data obtained by this method has shown that it provides dependable information for applying brushes to machines, and for analyzing many of the difficulties encountered. These data are especially useful in indicating where trouble may be experienced in the application of new brush materials.

47-123—The Horsepower Output of Polyphase Induction Motors; *R. C. Robinson (M '45). 25 cents.* The horsepower that may be obtained from a given induction motor will depend mainly on its full load temperature rise which, in turn, will depend on the motor losses and the effectiveness of its ventilation. By establishing the manner in which losses and ventilation change with the physical size and speed of machines a simple empirical method is given for calculating the approximate temperature rise of any induction motor. The familiar D^2l equation for horsepower output is discussed from the point of view of temperature rise and a new form of equation is suggested which takes into account both ventilation and motor losses. The designer is thus provided with a method for choosing the major dimensions of any induction motor without having to rely on previous test information.

47-125—Hiperco—A Magnetic Alloy; *J. K. Stanley, T. D. Yensen (M '23). 20 cents.* Hiperco is an improved iron-cobalt alloy specifically developed for electric machinery applications, where weight or space is at a premium. The basic composition is 34.5–35.5 per cent cobalt with an alloying element such as chromium added to improve hot and cold workability and increase electrical resistance. Processes have been developed whereby the alloy can be cold rolled to any desired gauge. Because of its high magnetic saturation value (over 12 per cent higher than iron), its unusually high permeability for magnetizing forces in the range $H = 10$ to $H = 400$ oersteds, and because of its low losses at high inductions, Hiperco will enable manufacturers to produce motors and generators considerably lighter in weight than by using present standard materials.

47-126—Interlaminar Eddy Current Loss in Laminated Cores; *A. C. Beiler (A '47), P. L. Schmidt (A '47). 20 cents.* Methods of measuring interlaminar electrical resistance of silicon steel laminations for electric machines are discussed and reasons are advanced for measuring two laminations or strips at a time. A method of statistical analysis of the results, including the plotting of logarithmic-probability curves, is described and the significance of different types of curves is illustrated. It is shown that one may calculate the core loss due to interlaminar eddy currents by making use of the resistance corresponding to the average conductance as determined from properties of the logarithmic-probability curves, and that the estimate is more reliable than those obtained by conventional methods. The way in which one may estimate the danger from hot spots in a machine from properties of the logarithmic-probability curve is demonstrated, as well as the method of setting limits which tests of interlaminar resistance must meet in order to restrict interlaminar eddy current losses to a given percentage of the rated iron loss of the material which is used.

47-127—Preliminary Report on Laboratory Aging Tests on Class "A" Insulation; *An AIEE Committee Report. 20 cents.* The paper gives the results of a series of co-operative laboratory aging tests made on manila paper in oil sealed in glass tubes at 100 degrees centigrade, 120 degrees centigrade, and 135 degrees centigrade. The co-operating organizations were the General Electric Company, Westinghouse Electric Corporation, Allis-Chalmers Manufacturing Company, and Armour Research Foundation. The changes in tensile strength, elongation, folding strength, oil color, and oil acidity are given in tabular form in Tables I, II and III. The tensile strengths of the paper in per cent of initial as a function of time are plotted in Figures 1, 2, and 3. The 120 degrees centigrade and 135 degrees centigrade tests are completed. The 100 degrees centigrade tests are being continued.

47-132—Silicone Insulation as Applied to Naval Electric Power Equipment; *H. P. Walker. 20 cents.* This paper discusses the general problem of shipboard electric equipment in relation to the use of silicone insulation as a possible means of providing smaller, lighter weight equipment. The progress that has been made in the development of certain silicone products is described, giving test data on properties of the insulation as well as performance data on silicone insulated transformers and rotating equipment. It is the purpose of this paper to present the experience of the Navy Department Bureau of Ships, in the design and testing of electric power equipment based on the use of silicone insulation.

47-139—Typical Transformer Faults and Gas Detector Relay Protection; *J. T. Madill (A '41). 25 cents.* This paper describes in detail a number of types of faults which have occurred in large trans-

formers of the 154,000-volt class on the Saguenay system. Cases are noted where gas detector relay protection would have definite advantages, particularly with regard to detecting incipient faults. Some conclusions are noted regarding the value of this type of protection, based on faults selected from operating experience with 124 large transformers over a period of 1,070 transformer-years of 26,200,000 kilovolt-ampere-years. Illustrations of incipient faults which have been detected by gas relays are included with this paper.

47-144—High-Voltage Power-Transformer Design—II; *M. B. Mallett (M '37). 25 cents.* This paper—a continuation of an earlier paper with the same title—deals with the distributed concentric type of power transformer design. This type of design is chiefly suited for the larger sizes of power transformers in voltage classes of 138 kv and higher. Principal points covered in the paper are:

1. Impulse voltage *distribution* tests made at low voltage have been adopted as standard commercial tests for distributed concentric-type transformers.

2. A porous insulating cylinder has been developed for application in the major insulation structure of the distributed concentric-type transformer.

3. Commercial application of the basic design has been extended to now include transformers in the 138-kv, 161-kv, and 230-kv voltage classes.

4. Field experience with distributed concentric-type transformers during the past four years is reported.

Electronics

47-159-ACO—High Frequency Heating in the Radio Spectrum; *W. C. Rudd (A '34). 25 cents.* One of the major activities of the electronic heating subcommittee of the AIEE electronics committee has been the study of engineering specifications involved in establishing regulations on allowable radio interference from high-frequency heating apparatus. This study culminated at a hearing conducted by the Federal Communications Commission in Washington, D. C., December 17, 1946. At this hearing, the members of this AIEE group, along with individual manufacturers and others, presented the results of their study for consideration by the Federal Communications Commission. The electronic heating subcommittee consists of both manufacturers and users of induction and dielectric heating apparatus who have gathered together most interesting and valuable data on this subject of radio interference. The results of this study are contained in the subject paper written by the secretary of this committee. It explains in fundamental language the important and universal use of induction and dielectric heating, balanced by an explanation of high-frequency radiation which results in varying degrees of radio interference. The general problem involved and methods of dealing with this problem are most interestingly portrayed in this paper on high frequency heating in the radio spectrum.

Industrial Control Devices

47-128—Rotating Stability Regulators for Synchronous Motor Drives; *W. Schaelchlin (M '46). 20 cents.* The author points out the desirability of regulating the stability of synchronous motor drives by adjusting the excitation as a function of load. After discussing briefly the relation between motor torque and displacement of the voltage vectors and calling attention to the proper relation between voltage and current for constant steady-state stability, the paper describes in detail the application of the Rototrol for regulating the stability of a synchronous motor drive for ship propulsion. Emphasis is laid on the importance of using current compensation which results in a fast response of excitation with a minimum of regulator amplification. Diagrams are added to illustrate the connections for variable and constant speed drives.

47-133—Dynamic Braking of Two D-C Series Motors; *John D. Leitch (M '42). 20 cents.* The paper is a continuation of that presented at the January 27–31, 1947 winter meeting in New York in which the author discussed the various methods of providing dynamic braking on drives using a single d-c series motor. On many drives such as crane bridges or ore bridge trolleys, two motors are used. They may be connected permanently in series or in parallel, or they may be connected in series initially and later in parallel to obtain higher speeds. Should it be imperative to obtain dynamic braking in either direction on power failure even while operating the drive with one motor only, single-motor methods must be used. If this restriction is removed, various circuits may be employed which are applicable only to 2-motor drives, or drives with a multiple of two motors. These circuits are described in detail.

47-134—Control of Slip Ring Motors by Means of Unbalanced Primary Voltages; *N. L. Schmitz (A '43). 40 cents.* This paper describes and analyzes a means of controlling a slip-ring motor to provide simple and economical a-c operation of hoists, drawbenches, and similar machines. The motor is controlled by applying adjustable, unbalanced voltages to its primary windings. The unbalanced voltages are obtained by using only a single phase autotransformer in addition to other standard devices associated with slip-ring motor control. The secondary windings of the motor are ordinarily connected to a resistor, and in this manner, speed-torque characteristics providing full-load landing speeds as low as 50 per cent of synchronous speed are obtainable for operating hoists. These characteristics do not involve the danger of accidentally hoisting an empty hook. Similar characteristics suitable for both hoists and drawbenches permit no-load speeds at any point between standstill and synchronous speed; also kickoff or motoring torques up to 150 per cent of rated motor torque. The paper shows that in some types of hoists, where a wide speed range is needed, capacitance and inductance can be connected in series with the secondary resistor to reduce the landing speed to 18 per cent. This feature of operation is explained and analyzed by means of a generalized equivalent circuit of the induction motor. A means of calculating torques and primary and secondary current loci is shown, and experimental and calculated results are compared.

47-141—Some Fundamentals of a Theory of the Transductor or Magnetic Amplifier; *A. Uno Lamm (A '35). 30 cents.* The old d-c presaturated reactor has experienced a revival with the appearance of the metallic rectifier. The combination of these two devices is studied with an idealized magnetization curve as a basis. Two typical connections are chosen as examples, namely one polyphase connection without self-excitation and one single-phase connection with self-excitation. The behavior is very similar to that of grid-controlled rectifiers. There is a marked difference as to the dynamic properties of the two connections. Much more rapid response is obtained at correct design than generally expected, making the application to quick-acting regulators often quite possible.

Industrial Power Applications

47-122—Data on the High-Frequency Resistance of Coils; *W. F. Witzig (A '41). 30 cents.* The resistance of various coils wound with copper tubing and strap was measured at frequencies up to 500 kc. These coil resistance data are presented graphically as a function of frequency. Other factors affecting coil resistance are discussed. Some of these factors are: resonance, coil geometry, and a coil load as experienced in induction heating. An equation for the resistance of a coil wound with strap was derived and found to be in good agreement with measured values of the coil resistance. For coils wound with tubing the coil resistance data led to an empirical method for determining the resistance. These methods simplify the heretofore complex calculation of coil resistance.

47-129—Automatic Operation of Electric Boilers; *M. Eaton (A '44). 25 cents.* Electric boilers, of the water-resistance type, are used extensively as a means for utilizing hydroelectric surplus power. Few of them have been equipped with automatic control, mainly because the effective application of automatic apparatus has proved to be difficult. This paper discusses the basic principles of automatic control with reference to the electric boiler application. Early methods of automatically regulating electric boilers are reviewed, showing their limitations as determined by standards established more recently. The development of controlling

means based on fundamental principles is described.

47-138—Electric Furnace Practice in Canada; *J. L. Balleny. 30 cents.* The use of electricity for metallurgical processes has been encouraged in Canada by an abundance of low-cost power, and this paper describes and illustrates some of the interesting electrometallurgical furnace installations, both in the melting and in the heat treating fields. Continuous strip annealing in a tower-type furnace is described, while wire-patenting by the direct-resistance method illustrates a different arrangement with the wires forming the resistance heating path. Heat treatment of aluminum alloys calls for a fast quench, so the quench tank may be located directly below the heating chamber, as illustrated. Photographs show that short-cycle malleable-iron annealing is done both in double-chamber elevator and in continuous type furnaces. A 9,600-cycle induction heater is used to heat drill bits prior to forging and hardening. Arc melting furnaces are described, with particular reference to a continuous type of regulating controller.

47-157-ACO—Report on Industrial Voltage Requirements; *An AIEE Committee Report. 40 cents.* (No abstract furnished.)

47-158—Dielectric Heating—the Measurement of Loss Under Rising Temperatures; *J. B. Whitehead (F'12). 20 cents.* In the applications of dielectric heating to various industrial processes, alternating frequencies between 1 and 30 megacycles, and rates of temperature rise of 50 degrees Fahrenheit and upward, are common. The properties of dielectric materials vary widely under these conditions, as must also the magnitude and character of the load on the source of high-frequency power. Methods so far proposed for the measurement of dielectric properties at high frequencies, are commonly restricted to low electrical stresses and constant temperature, and so are not available for a rapid heating cycle. The present paper describes a calorimetric substitution method for the measurement of power, dielectric constant, loss, and power factors over the heating cycles of a well-known industrial process. Interesting variations of dielectric properties are revealed.

47-167-ACO—Electric Equipment in the Finishing Room; *F. Winterburn. 20 cents.* "Electric Equipment in the Finishing Room" is intended to cover a description of the operation of the various machines and the electric equipment involved in the production of some of the many grades of fine paper. It describes the extensive application of the wound rotor induction motor to suit such operations as super-calendering, rotary cutting, embossing, and conditioning, and the use of squirrel-cage induction motors on trimmers and platers. An explanation is made of the advantages of the liquid rheostat for slow speed control and smooth acceleration in its application to wound rotor motor drives. Brushing-coating and the air-jet method of producing high gloss graphic art paper is covered in detail and such items as static eliminators, electric trucks, and lighting are touched upon in their relation to the fine paper industry. Although there are many other more modern electric installations to be found in finishing rooms, those described are to be seen in the majority of mills manufacturing or processing fancy finished papers.

Instruments and Measurements

47-116—Metering With Transformer-Loss Compensators; *G. B. Schleicher (M'34). 35 cents.* Economic advantages may be achieved in many cases by metering high-voltage loads on the low-voltage side of the power transformer banks. A transformer-loss compensator connected into the meter circuits on the low-voltage side causes the watt-hour meter to include the transformer losses in its registration. The meter itself retains its integrity as a standard watt-hour meter, and the compensator is calibrated from the loss data of the installation. The paper covers the principles involved, and practical and technical considerations pertinent to the method. The effect on losses of transformer connections and taps is discussed. Performance data and sample calculations are included, and connections are shown for various types of circuits. The principle may be extended to include var-hour measurements. The paper gives technical guidance for applying the method to any system of meter testing practice.

47-119—Quantitative Determination of Magnetic Properties by Use of Cathode-Ray Oscilloscope; *Joseph Zamsky (A'43). 20 cents.* This paper describes a means of producing the core loss loops of samples of magnetic strips on an oscilloscope screen and a method of obtaining the heat loss from the areas of these loops. The standard Epstein test for obtaining the core loss requires a correction for corner effects due to stacking of the laminations, whereas the method described here circumvents this problem by utilizing only the center portion of a relatively few short strips of the test material. Since quantitative measurements are made, circuit refinements, such as negligible phase shift couplings between amplifier stages and stabilized voltage supplies, are incorporated into the circuits.

47-136—A Self-Balancing Capacitance Bridge; *A. H. Foley (A'41). 20 cents.* A self-balancing capacitance bridge combines the advantages of the quick indicating capacitance meter and the precision wide-range capacitance bridge. Features include high accuracy, a greatly expanded scale representing an improvement of some 3,000 per cent over conventional capacitance meters, and an average balancing time of less than two seconds. The new instrument is arranged so that the nominal capacitance of the group of units to be tested can be set on appropriate direct reading decade dials. After balance the main dial indicates the per cent deviation from the nominal capacitance. Based on a simple capacitance bridge network all adjustments are made in the resistance arms. Bridge unbalance voltages are fed through a polarized amplifier to a motor which is coupled mechanically to the bridge balancing resistance. Balance is then achieved in accordance with the principles of servomechanism.

47-137—Electronic Telemetering System; *G. E. Foster (A'32), W. M. Kiefer (A'39). 20 cents.* An electronic impulse-type telewattmeter is described which originates impulses photoelectrically from individual generator watthour meters. Impulse rates from several watthour meters are totalized electronically to produce rates proportional to total station loads or to the combined load of several generating stations. Strip chart recorders controlled by electronic impulse conversion units provide readings accurate to 1/2 per cent of the load value. Demand meters are operated by low rate impulses obtained from electronic impulse rate dividers. This impulse system could be used to telemeter, totalize, and indicate any quantities or functions which can be expressed as impulse rates.

47-151—A Simplified Double-Film Klydonograph With an Improved Coupling Method; *J. H. Waghorne. 20 cents.* Two improvements in klydonograph surge recording are described. The first is a simplified double electrode recording unit in which a rubber band is used to hold the unit together and make it light-tight and weatherproof. The second is a coupling unit used for high-voltage lines and equipment which greatly facilitates the use of the klydonographs by connecting them on the line side of the capacitance voltage divider.

47-169—Applications of the Electrodynamic Instrument Mechanism; *A. J. Corson (M'43), N. P. Millar (A'44). 25 cents.* The applications of the electrodynamic instrument mechanism with single field and moving coil circuits hitherto has been confined substantially to the measurement of active and reactive power. The mutual inductance of the system has been treated only as a source of error in such measurements. This paper shows how the mutual inductance of the system is utilized in new circuits for the measurement of frequency and such nonelectrical quantities as temperature. The description includes the basic circuit, theory of operation, with constants and characteristics of typical instruments.

Land Transportation

47-147—Trolley Coaches and PCC Streetcars Provide Successful City Transportation; *W. J. Clardy (M'39), 20 cents.* The importance of adequate city transportation is recognized. Successful

handling of the rapidly increasing travel during the war as well as the subsequent high level of traffic that has been maintained proved difficult. Trolley coaches and PCC streetcars were introduced in 1928 and 1936, respectively, and the total now exceeds 10,000. They established a high degree of availability and usefulness in meeting war demands and have a definite economic field of application for city transit ranging from 500 to 12,000 maximum passengers per hour in one direction. They use city streets efficiently and reduce traffic congestion. Operation is quiet, a feature which adds greatly to the comfort of the ride. The trolley coach has ample power for rapid accelerating at 3.5 miles per hour per second; it will run above 40 miles per hour, and normal stopping ability equals 3.5 miles per hour per second. The control provides quick, smooth starting and stopping. These performance details combine to produce schedule speeds of 12 to 15 miles per hour. Motor capacity of the PCC streetcar is liberal so as to readily permit 3.5 miles per hour per second starts. Car speeds exceed 40 miles per hour and service dynamic braking is at 3.15 miles per hour per second. The latter is supplemented by drum and track brakes. The 99-step control provides smooth starts and stops. These features combine to produce schedule speeds 25 per cent, or more, above those of old streetcars. A conservative saving in operating expenses for the trolley coach is three cents per vehicle mile in comparison with the motor bus. PCC streetcars effect savings in track and roadway maintenance, equipment maintenance, transportation costs, and accident expense when compared with old streetcars while power costs tend to increase. However, the important factor in each case is the gain in revenue that these modern vehicles will produce in competition with other means of travel, as demonstrated prior to the war. The economic advantages can be utilized in modernization programs and should be used more extensively.

47-148—Motor Control for New New York City Transit System Subway Cars; *L. G. Riley (M '45). 20 cents.* Early in 1948 The Board of Transportation of New York City will place in service the first of several hundred new subway cars, marking the postwar revival of one of the oldest and best established branches of the electric traction industry. Since the year 1900, more than 11,000 passenger cars have been built for the four large cities in the United States having rapid transit systems, a large percentage of which are still in service. An expansion program needs, therefore, to recognize and conform in general to established practices of operation, maintenance, and service conditions. This paper discusses the extent to which modern features of higher acceleration, dynamic braking, and smoother operation are being introduced without any major changes in the existing systems and operating methods.

47-153—Modern Railway Passenger-Car Auxiliary-Power Equipment; *D. R. MacLeod (M '41), Jack Hause (A '35). 30 cents.* There are approximately 3,000 passenger train cars on order for various railroads today. This tremendous building program was foreseen during the war and plans were made by the railroads and manufacturing companies. A large number of different ideas were given a quick tryout and adopted by different railroads. All these ideas had as their basis a very large increase in the amount of power which would be required for electric devices on the cars. The railroads long have realized the advantages of induction motors for use on passenger cars instead of commutator motors. The advantages of a-c power have been brought to their attention more forcefully in recent years by innovations such as fluorescent lighting, electric razors, radios, public address systems, and sound movies. This requirement for a-c power has led the railroads into many different methods of obtaining it, such as: head end power cars, engine-driven alternators on individual cars, motor alternator sets, vibrating reed-type inverters, amplidyne booster inverters or simple inverted synchronous converters, operating from the battery circuit.

47-154—The Design of New York Subway Motors for Dynamic Braking; *B. A. Widell (M '26). 20 cents.* Each of the new cars for New York City's Subway System will be equipped with four 100-horsepower self-ventilated traction motors, truck-mounted parallel to axle and connected through a flexible coupling to a separate gear reduction unit. The inherent advantages of such an arrangement are pointed out. The motors are of the high-speed type, similar but larger than those used on PCC cars, and are designed to provide dynamic braking from a top speed of 59 miles per hour to 10 miles per hour when it is allowed to fade out. The electrical design to insure successful dynamic braking is outlined and commutation constants are compared with those of older 2-motor equipments now operating in the subways. It is pointed out that higher permissible car speeds, and higher accelerating and braking rates in addition to dynamic braking will be obtained on the new cars without increasing the weight of motor equipment over that on the older type cars, consisting of two axle-hung motors. The relative hourly and continuous ratings per pound of motor complete with accessories of the new and old motors are shown on charts.

47-155—Proposed Rapid Transit System for Toronto; *W. E. P. Duncan. 30 cents.* The Toronto Transportation Commission plans to construct a rapid transit system to separate public transportation from other street traffic on two main routes in Toronto as follows:

1. A north and south line under or near Yonge Street from Front Street to Eglinton Avenue, a distance of 4.56 miles; partly in subway and partly in open-cut.
2. An east and west line under or near Queen Street from Trinity Park to Broadview Avenue, a distance of 4.54 miles; mainly in open-cut, but in subway through the center of the city.

The subway structures will be 2-track concrete box sections built as close to the surface as possible to facilitate transfer to surface transportation. Power for third rail operation will be 600-volt direct current converted by mercury arc rectifier substations from 13,200-volt 3-phase 25-cycle power. Cars for the Yonge Street subway will have specially designed bodies mounted on PCC trucks and utilizing PCC electric equipment. The Queen Street subway will be operated with standard surface street cars, but the structure will be designed to take larger cars eventually.

Machine Tools

47-130—The Application of Synchronous and Induction Motors to Chippers; *R. R. Baker, M. R. Lory (A '40). 30 cents.* Wood chippers require motors with special characteristics to operate under exacting conditions involving high peak loads, severe vibration, acceleration of high inertia, and exposure to dirt and moisture. Methods are given to select the most suitable size of chipper, to determine the proper rating and characteristics of a motor to drive it, to choose between synchronous and induction motors, and to select the mechanical arrangement of the drive. The modifications in mechanical construction of the motors to enable them to withstand the severe operating conditions are described and illustrated. Desirable features to be included in the control are given.

Power Generation

47-120—The Maintenance of Hydroelectric Generating Units; *A. S. Robertson (M '21), R. O. Standing. 25 cents.* This paper deals with the solutions of some of the more important of the electrical and mechanical maintenance problems which have occurred over the past 25 years on the systems of the Hydro-Electric Power Commission of Ontario. One section is devoted to the commission's experience with vertical thrust bearings. Many of the cases cited are typical of those encountered by the modern large hydroelectric utility. It is hoped that the material presented will be of practical use to operating engineers and designers of this type of equipment.

47-124—Hydroelectric Power Development in Quebec; *F. L. Lawton (M '36). 40 cents.* The paper presents an integrated picture of the relationship between physiography, precipitation, run-off, water-power resources, developed water powers and distribution with respect to the major power rivers, and the relationship of storage to power development in the province of Quebec. It notes the change from a few small isolated stations to the

present co-ordinated development with the interconnected Montreal-Shawinigan-Saguenay System, one of the greatest hydroelectric power pools in the world. The loads carried by the hydroelectric power systems (which constitute the entire generating plant, there being no steam power stations), the type of transmission networks, and the extent of interconnection are presented in some detail. Unusual features of the power networks, such as the Montreal 120-kv cable and the 220/-165-kv series transformers forming the essential tie between the Saguenay-Shawinigan systems, are noted. Attention is drawn to progress in water wheel design, ice troubles, and operating techniques.

47-135—The German Electrical Utility Industry During World War II; *John G. Noest (M'36).* *35 cents.* The German utility industry entered World War II with the expectation of a short war. Immediately at the beginning of the European phase of the war, the over-all operation of the physical plant was taken over by governmental authority with the setting up of a national load dispatcher, whose principal function was the establishment of nation-wide interconnected operation for the purpose of achieving maximum utilization of existing capacity. In spite of all efforts, capacity slowly deteriorated, plant expansion and new plant construction lagged, and nation-wide interconnected operation failed to materialize, until severe damage to plant during the last month of the war lead to complete collapse.

47-168—Factors in the Economic Supply of Energy in Hydroelectric Systems; *A. H. Frampton (F'45), G. D. Floyd (M'28).* *25 cents.* This paper discusses those factors which affect the economy of energy generation (as distinct from peak generation) in the hydroelectric system, under three broad headings:

1. Factors in the design.
2. Factors in operation.
3. Factors in the load.

Included in the first are storage problems, efficiency of plant arrangement, unit efficiency, and the design of the new plant to combine most effectively with existing resources. The economic comparison of a hydroelectric with a thermoelectric plant is illustrated by a typical example. Factors in operation include operation of units in a plant to obtain maximum energy delivery, economic operation of plants in parallel, effect of maintenance, and of load and frequency control. The factors in the load covered are: effect of seasonal variation of energy demand; provision of "peak" reserve capacity; development of "off-peak" consumption; and effect of secondary, or surplus energy, in reducing the cost of primary generation, utilizing the energy in surplus water which is otherwise lost.

Power Transmission and Distribution

47-114—Lightning Investigation on the 25-Kv System of the West Penn Power Company; *W. C. Bowen (M'30), Edward Beck (M'35).* *20 cents.* In 1939, the West Penn Power Company, with the co-operation of the Westinghouse Electric Corporation, began an investigation of the frequency and character of the currents discharged by lightning arresters in the company's 25-kv substations. The study discussed in this paper involves four substations. Three of these were equipped with fulchronographs, surge crest ammeters, surge front recorder, photographic surge current recorder, and paper recorder. The fourth was equipped only with the paper recorder. The study covers 26 3-pole arrester-years with 154 discharges indicated by paper or other recorders, of which 18 3-pole arrester-years yielded 34 fulchronograph records. The data also include 90 records of single-pole arrester operation covering 54 single-pole arrester-years. The results of the investigation are presented in statistical form by means of curves.

47-115—Lightning and 60-Cycle Power Tests on Wood-Pole Line Insulation; *P. L. Bellaschi (F'40).* *35 cents.* Since 1931 various investigations have been conducted at the Sharon High-Voltage Laboratory on wood-line insulation both from a lightning standpoint and regarding the power-quenching ability, leakage effects, and other significant characteristics. The more pertinent findings are presented in the paper. The three major factors that determine the impulse strength of wood are: length of wood, duration of impulse, and moisture content in wood. Laboratory tests indicate that the extent of shattering of wood from lightning seems to be limited. Power-quenching tests made with an impulse generator in combination with a 2,500-kva, 230-kv or 18,000-kva, 100-kv transformer show that for an average unit stress of 0.5 kv rms per inch (power voltage divided by arc-over path) the probability of power follow is practically zero for single impulse discharges. However, in projecting the experimental findings to the application field consideration must be given to additional factors underlying service. Finally, the paper presents data on leakage currents and deionization of the arc.

47-117—Performance of Tennessee Valley Authority 161-Kv and 115-Kv Transmission Lines; *K. E. Hapgood (F'44), C. P. Almon, Jr. (M'45).* *25 cents.* This paper covers engineering features and lightning performance record of 37 161-kv and 18 115-kv lines over a period of seven years. The isokeraunic level varies from 55 to 65. The use of automatic oscillographs and signal relays for determining location and types of faults is discussed briefly. Line loadings are given. Counterpoise is used on some 161-kv lines. A definite decrease in lightning outages is obtained by use of counterpoise. On steel tower lines having an average resistance of 50 ohms or less, there is little to be gained by adding counterpoise. Forty per cent of faults on 161 kv, due to lightning, are single phase to ground. The automatic oscillograph provides information for improvement in design and performance. The performance characteristics of an individual line, as related to design and operation, should be determined on the basis of the line location and function with respect to the system.

47-143—Galloping Conductors and a Method for Studying Them; *E. L. Tornquist (M'42), C. Becker.* *35 cents.* This paper presents the results of a study of the large amplitude oscillations of aerial conductors called galloping. A full scale 4-span 3-conductor suspension-insulator experimental transmission line is described which is so constructed that, without ice formation, it will gallop typically and vigorously in winds of seven to ten miles per hour and higher velocity. Amplitude, frequency, and other data taken on this line are given, together with sketches showing the conductor motions observed. This line provides a means for direct study of methods of mitigation. The theory and laboratory experiments upon which the design of the line was based are presented. The opinion is expressed that galloping, which is known to occur under a variety of conditions, is not in all cases explained adequately by published theories. Some of these theories and the general aerodynamics of galloping are discussed briefly.

47-162—Electronic Stabilizer for Power Transmission; *E. F. W. Alexanderson (F'20), D. C. Prince (F'26).* *20 cents.* Voltage regulation of an alternator historically has depended upon variation of the field current, and high-speed regulators have been developed in order to improve synchronous stability. This paper describes a voltage control brought about by varying the output current. Load is varied electronically in such a way as to maintain the desired voltage and line current. Whereas regulation by field control is limited by the long time constant of the field winding, the electronic stabilizer acts upon the transient reactance and therefore it has the fast response needed to regulate the terminal voltage. The paper describes a new method fo- increasing the stability limits by supplementing present known methods and extending the limits of a-c power transmission. The electronic stabilizer is intended to take care of certain regulating functions which cannot be performed by a field regulator. The use of the two in combination, therefore, can be expected to yield still further improvement. No attempt has been made to compare this method with other methods of compensating the line and it is intended that these methods may be used in combination. Tests of a model equipment are described. A rough comparison has been made between this system and the use of series capacitors. Using present costs and parameters, the cost of the series capacitors

was somewhat less. Further cost changes may alter this comparison, or there may be cases where series capacitors are not acceptable.

47-163—Economics of Long-Distance A-C Power Transmission; *S. B. Crary (F'45), I. B. Johnson (M'45). 30 cents.* This paper summarizes the results of economic studies of a-c power transmission for distances from 100 to 600 miles. Particular emphasis is placed on the economics of higher voltages. It is shown that costs of energy transmission in mils per kilowatt-hour is essentially linear for distances from 100 to 600 miles, and that the minimum cost of transmission is obtained when using voltage levels of 230, 287, and 360 kv at high circuit loadings and load factors.

47-164—The Probable Breakdown Voltage of Paper Dielectric Capacitors; *Hamilton Brooks (M'46). 30 cents.* The frequency of occurrence of defects in electrical insulation follows the Poisson law of probability. One of the more important defects in thin paper insulation is conducting particles. In this paper expressions are derived for the probable breakdown voltage as a function of conducting particle occurrence. It is shown by statistical evidence that large conducting particles exist in the insulating paper and bridge one or more layers of paper in the finished capacitor through chance reorientation caused by manufacturing processes and operation. The degree and frequency of reorientation of particles with a typical grade of paper is determined experimentally, and the probable insulation thickness and consequent voltage strength of various size capacitors is calculated. A method of determining the optimum voltage strength of this insulation is illustrated. It is concluded that conducting particles are a predominant factor in determining the voltage strength of present day capacitors and that one of the greatest opportunities for improvement lies in the reduction of the conducting particle content in the paper.

Power System Applications of Carrier Current

47-142—Operation of Power Line Carrier Channels; *H. W. Lensner (A'43). 25 cents.* The widespread use of carrier on power systems for relaying as well as several auxiliary functions has brought up a variety of problems in connection with establishing and maintaining a dependable carrier channel. The characteristics of the average power system make it far from ideal as a carrier circuit, and tests often must be made to determine a carrier frequency which will be satisfactory under various conditions of line switching. Two methods of making a frequency attenuation test of a line are described, one of which requires no additional instruments beyond those supplied with standard carrier equipment. After carrier equipment has been installed and adjusted, periodic manual or automatic checks are desirable to assure continuity of service. Several operating procedures in common use today are described. Certain features of carrier application, such as two frequency operation and carrier on power cables, are also discussed.

Protective Devices

44-118—Selective Tripping of Low-Voltage Air Circuit Breakers; *William Deans (F'30). 25 cents.* Selective or sequential tripping in low-voltage air circuit breaker application provides for removal from the system of a faulted part only; the rest of the system is left in operation. Present standard circuit breakers generally are not suitable. Solution of the problem is through direct acting series tripping means with distinct current-time characteristics in ranges of overcurrent and fault-current, with minimum time to complete interruption. Modified standard circuit breakers may be applied to selective tripping, with application limitations based upon rated interrupting capacity and series trip coil rating. They may be applied with relay schemes requiring delayed tripping. Little is gained by combining selective tripping with cascade arrangement so it is recommended that for a particular installation, one or the other be used, choice based upon weighed advantages of each.

47-145—An Improved Overcurrent Tripping Device for Low-Voltage Circuit Breakers; *H. L. Rawlins (M'41), Jerome Sandin (M'46). 20 cents.* The necessity for greater service continuity on low-voltage systems has focused attention on the limitations of present delayed overcurrent tripping devices and created a demand for their improvement. This paper reviews the limitations of present devices and states the requirements for delayed overcurrent trips. A new device meeting all of the requirements is described and its characteristics shown. The new device is universal in its application in that the same elements provide for breaker selectivity up to the highest values of fault current and yet give correct timing to permit motor starting. Tests are described which show the adequacy of the new device for its intended service as well as indicating an unusual degree or reliability.

47-149—Relay Protection of Power Transformers; *An AIEE Committee Report. 20 cents.* The relay subcommittee of the AIEE protective devices committee has completed a 3-year investigation of transformer relay protection, including a review of the characteristics and limitations of available devices and methods, and an analysis of desirable improvements. This final report is based on a survey covering experience with 56 million kilovolt-amperes of power transformers, and on information developed through an interim report presented in January 1946 and through two subsequent conference sessions. Differential protection remains the generally accepted method, but improvements are needed to overcome its limitations, especially interference with sensitivity caused by magnetizing inrush currents. This problem is accentuated by modern trends toward higher flux density permissible with improved transformer iron and by greater concentrations of system capacity. Increasing interest is found in various forms of supplemental protection such as pressure and thermal relays and gas detector elements.

47-156-ACO—A Development in 5,000-Volt Metal-Clad Switchgear; *Ralph G. Lockett (M'37), J. D. Wood (M'27). 20 cents.* Since the installation of the first 2,500-volt air circuit breakers at Logan, W. Va., in 1937, there has been a great increase in the use of oilless circuit breakers for indoor power applications. This paper gives the design features of the circuit breaker and its operating characteristics, and also briefly describes the switchgear in which it is mounted. The circuit breaker tests for both low magnetizing and exciting currents and full interrupting capacity at the different operating voltages are shown. The method of current interruption is described. The design provides that the interrupter plates are not subject to voltage stress when the circuit breaker is in the open position.

47-173—Performance Criteria of D-C Interrupters; *E. W. Boehne (F'43), M. J. Jang (A'44). 35 cents.* The present development of d-c interrupters has progressed largely due to the excellence of empirical studies and, as a result, very little numerical analysis has been made of the circuital problems associated with their design, performance, and application. It is the purpose of this paper to create an analytical foundation for many of the well-known and a few of the lesser known performance criteria of d-c interrupters. The study considers only linear circuits external to the interrupter and employs to the fullest extent the principle of superposition as an analytical tool. The non-linear resistance characteristics of the arc of the interrupter are present but the method of analysis avoids this complication by considering the arc voltage characteristic of the interrupter as the salient design characteristic. The work is presented in a compact useful form of interest to the student of circuit theory as well as the practical engineer.

Safety

47-170—Hazards of Static Electricity in Hospital Operating Rooms; *H. B. Williams (M'41). 20 cents.* Fatal explosions of mixtures of anesthetic gases and oxygen have occurred in hospital operating rooms. Most of these have been traced to sparks due to discharge of electrostatic charges. Grounding of personnel and equipment is recommended, but must be thorough and carefully maintained or it may produce a condition more danger-

ous than would lack of this precaution. The spark energy required to explode a stoichiometric mixture of oxygen and cyclopropane is very small. The explosion wave travels with great speed and cannot be stopped by a Davy lamp gauze.

47-172-ACO—The Hazards of Static Electricity in Grain Handling and Grain Processing Plants; *C. M. Park (A '27). 20 cents.* In grain and milling plants, static electricity is found not only on belts, but also in grain and other stocks passing through handling and processing equipment, in dust-laden air in ducts, and on ungrounded metallic objects adjacent to or in contact with belts, moving stock, or moving dust-laden air. Fire and explosion hazards and personal injury hazards are introduced when accumulated static charges on ungrounded metallic objects are discharged periodically in the form of hot sparks. When relative humidity is higher than 50 per cent, leakage through surface moisture prevents accumulation of dangerous charges, and where practicable, humidification is an effective means for controlling static. Where relative humidity may fall below 50 per cent, and where humidification is not practicable, use of conducting rubber belts and grounding of all ungrounded metallic objects exposed to static accumulations will control effectively the static electricity hazard.

Servomechanisms

47-165—The Analysis and an Optimum Synthesis of Linear Servomechanisms; *Donald Herr (M '47), Irving Georst. 40 cents.* The concepts of minimum band width and nonminimum band width servomechanisms are introduced. Minimum band width servomechanisms are dealt with in this paper. A systematized approach to the synthesis of such servomechanisms is outlined and the method applied and detailed results obtained for one practical class of such servomechanisms. The technique enables the stability requirements and the accuracy requirements to be considered separately in succession. An engineering criterion of servomechanism stability is enunciated. The critical design parameters and performance characteristics, including amplitude and phase margins, are tabulated for a practical class of minimum band width servomechanisms over the range of degree of stability of engineering interest. The corresponding build-up times, damping factors, and natural frequencies are also tabulated. Extensions of the viewpoint and method described are outlined.

Standards

47-161-ACO—On Definitions of Magnitudes Characterizing the Behavior of Circuit Breakers Under Abnormal Conditions in American and Other Standards; *S. Gerszonowicz (M '44). 30 cents.* American industrial equipment is used now in foreign countries far more than before the war, and is going to be used even more in the future. The difference between American and European standards create some difficulties which it would be worthwhile to remove. The ultimate goal should be to have uniform standards, reflecting the common theoretical background of industrial design and operation, and the same best engineering solutions. It is probably the right moment to attack the problem, state the differences, and try to find solutions which will prove satisfactory in all places. It is our purpose in this paper to compare critically the definitions concerning the magnitudes which characterize the behaviour of circuit breakers under abnormal conditions, such as opening of, or closing on, a short circuit. The European standards do not differ much from the International Electrotechnical Commission standards, and therefore the present comparison will be made chiefly between the American and IEC standards; however British, French, or German standards will also be considered when convenient.

PERSONAL • • • • •

H. C. Schlaikjer (A '28, M '34) engineer in the distribution operation department, Consolidated Edison Company of New York (N. Y.), Inc., has been transferred to gas production as superintendent's assistant. **T. C. Duncan** (A '30) formerly division engineer in the system engineering department, has been transferred to station construction and shops as assistant engineer. **M. L. Waring** (A '29, M '36) formerly superintendent's assistant in the distribution operation department, has been transferred to system engineering as planning engineer. **H. A. Bauman** (A '26, M '41) formerly test engineer in the process engineering department, has been made superintendent *B* at the company's Sherman Creek station. **W. T. Grumbly** (A '28, M '36) formerly assistant inside plant engineer in the electric engineering department, has been transferred to gas production as a superintendent's assistant. **G. V. Morton, Jr.** (A '32) formerly assistant engineer in the electrical engineering department, has been transferred to electric production at the Hell Gate station. **D. V. Buchanan** (A '39, M '45) formerly assistant engineer in electric production, has been transferred to the outside plant construction department as superintendent's assistant.

P. R. Pollock (A '43) formerly field engineer, Allis-Chalmers Manufacturing Company, Washington, D. C., has been named manager of the Denver, Colo., office of the company. **H. H. Roth** (A '40) formerly district manager at Denver, has been transferred to the company's main works in West Allis, Wis. **A. D. Brown** (A '31, M'45) formerly manager of the Los Angeles, Calif., district office, has been transferred to Washington, D. C., as district manager. Mr. Brown, who has been manager at Los Angeles since 1936, previously was manager of the Buffalo, N. Y., office and public utility specialist in the New York, N. Y., office. **C. W. Schweers** (A '37) formerly district manager, Houston, Tex., succeeds Mr. Brown. **I. C. Matheson** (A '42) formerly sales engineer of the Tampa, Fla., district office, also has been transferred to Los Angeles where he will specialize in utility problems. **A. D. Robertson** (A '39) formerly assistant manager, Norwood (Ohio) Motor Division, of the company, has been named manager of the Tampa district. Other district managers recently appointed in the new regional field organization for the general machinery division of the Allis-Chalmers Company are: **W. R. Horrigan** (A '45) for the Amarillo, Tex., office; **Aubrey Phillips** (A '44) transferred from Beaumont to the Houston, Tex., office.

T. M. Linville (A '27, M '34) formerly electrical engineer, motor and generator engineering department, General Electric Company, Schenectady, N. Y., has been named staff assistant to the manager of engineering, apparatus department. Mr. Linville, who was graduated from the University of Virginia in 1926, joined the company as a student engineer. He has been assigned to the motor engineering division, Pittsfield, Mass.; the engineering general division; and the Philadelphia (Pa.) district office. Mr. Linville was a member of the United States Naval Technical Missions at Pearl Harbor, Hawaiian Islands, in 1942, and in Europe in 1945. He received a General Electric Coffin Award in 1946 for "outstanding development of design methods for d-c machines and application to propulsion machines for submarines in World War II."

P. P. Paisley (A '45) technical director and director of Mica Company of Canada, Ltd., has been appointed managing director of that corporation's new subsidiary, Universal Insulations Limited, Toronto, Ontario. A 1937 graduate of the University of To-

Milne

P. P. Paisley

ronto, Mr. Paisley previously has been associated with the Stromberg-Carlson Radio Company, Ltd., Toronto; the Rogers-Majestic Radio Corporation, Toronto; the Restigouche Company, Campbellton, New Brunswick; Filtration Laboratories, Toronto; and E. S. and A. Robinson, Leaside, Ontario. He joined the Mica Company in 1944. He is a member of the American Chemical Society, the Chemical Institute of Canada, the Canadian Ceramic Society, and the Toronto Young Men's Board of Trade.

O. A. Boyer (M '42) formerly chief engineer, Oklahoma Power and Water Company, Sands Spring, has been elected a vice-president and director of the company. Mr. Boyer succeeds **T. E. Mansfield** (M '37) who has joined the Central Power and Light Company, Corpus Christi, Tex., an affiliated company. Mr. Boyer was graduated from Oklahoma Agricultural and Mechanical College in 1930 and gained his first engineering experience in the student course of the Westinghouse Electric Corporation, East Pittsburgh, Pa. He afterwards operated an electrical contracting business in Cleveland, Okla., and in 1935 joined the Oklahoma Power Company. Mr. Mansfield joined the Oklahoma Company in 1929 after completing the student course at the General Electric Company, Schenectady, N. Y.

S. E. Gates (A '36, M '42) manager of the Los Angeles, Calif., office of the General Electric Company, has retired after 42 years with the company. Born in San Francisco, Calif., in 1880, Mr. Gates joined the General Electric Company in Schenectady, N. Y., in 1905, after his graduation from Purdue University. He was transferred to Portland, Oreg., in 1908 and the succeeding year opened the first company office in Boise, Idaho. He was manager of the Spokane, Wash., office of the company from 1910 to 1924 and in the latter year was transferred to Los Angeles. He is a past president of the Los Angeles Electric Club and the Los Angeles Engineers Club.

R. E. Hayman (M '44) has joined the Chickasha staff of the Public Service Company of Oklahoma as agricultural development engineer. A 1926 graduate of the Oklahoma Agricultural and Mechanical College, Mr. Hayman was manager of the rural service department of the Oklahoma Gas and Electric Company from 1927 to 1945. Mr. Hayman also is a former chairman of the farm utilization equipment committee of the Edison Electric Institute.

Samuel Rosenbach (A '23, M '29) formerly transmission and distribution engineer, Duquesne Light Company, Pittsburgh, Pa., has been appointed general engineer in the electrical engineering department. Mr. Rosenbach has been with the Duquesne Company since he was graduated from the University of New Mexico in 1922. He has held a research fellowship at the Carnegie Institute of Technology, Pittsburgh, and was instructor in mathematics in the evening session of the institute from 1921 to 1927. He is the author of a number of technical articles and is a member of Phi Beta Kappa.

G. J. Read

C. W. Dalzell

S. I. Lindell

G. J. Read (A '21, M '30) director of economic research, Consolidated Edison Company of New York (N. Y.), Inc., has been appointed general manager of Chelsea Products, Inc., Irvington, N. J. Mr. Read, a 1924 graduate of the University of Pittsburgh, had been associated with the Edison Company since 1927. He is a member of the American Statistical Association, the American Economic Association, and the Electrical and Gas Association of New York, Inc. He has served on committees of the Edison Electric Institute and was active in national and local affairs of the Committee on Economic Development.

C. W. Dalzell (A '27) formerly director of engineering, Heyer Industries, Inc., Belleville, N. J., has been appointed chief engineer of the Franklin Transformer Manufacturing Company, Minneapolis, Minn. Mr. Dalzell, who is a graduate of the University of Pittsburgh, previously was associated with the Union Switch and Signal Company, Swissvale, Pa., and with the Westinghouse Electric Corporation, East Pittsburgh, Pa. He joined the Heyer Company in 1935. He is a member of the Society of Automotive Engineers and the Instrument Society of America. More than a dozen patents have been issued in his name.

M. W. Smith (M '44) formerly superintendent of electric equipment, production and distribution department, Ohio Edison Company, Akron, has been appointed to the newly created position of superintendent of production and transmission construction, and **A. L. Richmond** (A '16) superintendent of electric operation, will assume Mr. Smith's former duties in addition to his own. Mr. Smith has been with the Ohio Edison Company since 1926, at which time he was appointed electrical superintendent. He became superintendent of electrical construction in 1937 and superintendent of electric equipment in 1943. Mr. Richmond has been superintendent of electric operation since 1930.

G. F. Maughmer (A '38) formerly assistant manager, has been appointed manager of the Los Angeles, Calif., office of the General Electric Company. Mr. Maughmer has been with the company since 1925 at Los Angeles and Phoenix, Ariz. He coordinated company activities on the Metropolitan Water District aqueduct and was granted a patent on certain ventilating equipment which he designed for that project, as well as receiving the Coffin award for his work.

B. G. Johnson (A '46) formerly electrical engineer, Houston (Tex.) Lighting and Power Company, recently became a partner in the firm of Howard, Johnson and Vogt, consulting electrical and mechanical engineers, Houston. A 1937 graduate of Texas Agricultural and Mechanical College, Mr. Johnson was associated with the Dow Chemical Company, Houston, until he entered the United States Army Signal Corps in 1941. He was released in 1945 with the rank of colonel and holds the bronze star medal for action in southern France. He is a member of the Texas Society of Professional Engineers.

J. B. Rees (M '31, F '32) assistant vice-president, American Telephone and Telegraph Company, New York, N. Y., has been appointed assistant chief engineer. **J. A. Parrott** (M '37) telephone engineer, has been placed in charge of the special services group for the American Company.

E. H. Kendall (M '36) line materials engineer, Commonwealth and Southern Corporation, Jackson, Mich., has been appointed chairman of the recently organized

subcommittee on records and editorial of the American Society for Testing Materials' Committee *B-1* on Wires for Electrical Conductors. **A. P. S. Bellis** (A '26) chief electrical engineer, John A. Roebling's Sons Company, Trenton, N. J., is chairman of the subcommittee on rods for processing into conductors, and **C. E. Ambelang** (M '44) electrical engineering department, Public Service Company of Northern Illinois, Chicago, chairman of the subcommittee on composite conductors of copper and steel.

S. I. Lindell (A '26) formerly consulting engineer, S & C Electric Company, Chicago, Ill., has been appointed chief engineer for the company. Mr. Lindell, who was born in Sweden and was graduated from the Technical College of Orebro in 1922, came to the United States in 1923 and entered the engineering department of the S & C Company in 1925. He has been occupied chiefly with the design, development, and application of high-voltage protective and interrupting equipment.

R. M. Darrin (A '28, M '34) formerly New York (N. Y.) district manager of the transportation division of the General Electric Company, has been appointed assistant New York district manager of the central station division. Mr. Darrin, who joined the General Electric Company in 1919, was manager of the Syracuse, N. Y., office of the company before he was transferred to New York in 1945.

R. M. Darrin

E. K. Cliver (A '43) formerly electrical engineer, Celanese Corporation of America, Newark, N. J., has joined the staff of Burns and Roe, Inc., New York, N. Y.

H. K. Doyle (M '38, F'45) formerly operating superintendent, Dallas (Tex.) Power and Light Company, has been appointed assistant to the president.

L. M. Keever (A '35, M '45) associate professor of electrical engineering, North Carolina State College of Agriculture and Engineering, Raleigh, has been elected secretary–treasurer of the North Carolina Society of Engineers.

R. W. Sherwood (A '46) formerly system standards engineer, Gulf States Utilities Company, Beaumont, Tex., has been appointed design engineer.

W. W. Eckles (M '39) formerly electrical engineer, system engineering department, Gulf States Utilities Company, Beaumont, Tex., has been appointed planning engineer.

Herman Halperin (A '21, F '45) staff engineer, Commonwealth Edison Company, Chicago, Ill., has been elected to the national honorary scientific society, Sigma Xi.

H. C. Graves, Jr. (A '23, M '43) formerly engineering manager, I-T-E Circuit Breaker Company, Philadelphia, Pa., has been appointed chief engineer for the Gibson Electric Company, Pittsburgh, Pa. Mr. Graves previously was associated with the Union Gas and Electric Company, Cincinnati, Ohio, and with the Westinghouse Electric Corporation, East Pittsburgh, Pa. He has been granted approximately 20 patents.

J. L. Taylor (M '45) formerly technical superintendent, Mid-Lincolnshire Electric Supply Company, Ltd., Grantham, England, has been appointed deputy engineer and manager for the City of Oxford Electricity Department. Previously associated with the Electric Construction Company, Ltd., Wolverhampton, Mr. Taylor joined the Mid-Lincolnshire Company in 1941 and was made technical superintendent in 1944.

F. A. Short (A '20, M '25) who has been electrical engineer with the California Industrial Accident Commission, Los Angeles, since 1918, has retired from that service to open his own consulting engineering office.

William Fondiller (M '15, F '26) assistant vice-president, Bell Telephone Laboratories, Inc., New York, N. Y., has been appointed a member of the committee on research of the department of electrical engineering, Columbia University, New York.

Gano Dunn (A '91, HM '45) president of the J. G. White Engineering Corporation, New York, N. Y., recently received the gold insignia of the Pan American Society as a symbol of special contribution to the cause of inter-American relations.

G. A. Kelsall (A '10) who retired from the technical staff of Bell Telephone Laboratories, Inc., New York, N. Y., in 1945, has been named a special lecturer in the mathematics department of the Newark (N. J.) College of Engineering.

S. H. White (A '29, M '39) of the engineering department, General Electric Company, Seattle, Wash., has received the Naval Ordnance Development Award. The award is the only one of its kind which has been given outside the naval service in the Seattle area.

R. O. Whitesell (A '44) chief engineer, rectifier division, P. R. Mallory Company, Indianapolis, Ind., for the past seven years, has become a partner in the sales engineering firm, Engineering Products, Indianapolis.

C. E. Canada (M '39) sales engineer, General Electric Company, Portland, Oreg., has been elected president of the Professional Engineers of Oregon for 1947.

L. C. Brewster (A '37) toll transmission engineer, Ohio Bell Telephone Company, Cleveland, has been appointed transmission and protection engineer.

Owen O'Neill (A '25, M '37) assistant engineer, Consolidated Edison Company of New York (N. Y.) Inc., recently completed 25 years of service with that company.

E. S. Bundy (A '14, F '33) vice-president and chief engineer, Buffalo (N. Y.), Niagara Electric Corporation, has been named a director of the company.

F. M. Tait (A '94, F '12) president and general manager, Dayton (Ohio) Power and Light Company, has been elected president of the Edison Pioneers.

C. S. Redding (A '12, M '41) president, Leeds and Northrup Company, Philadelphia, Pa., has received the honorary degree of doctor of science from the University of Pennsylvania.

E. F. Watson (A '19, M '30) formerly teletypewriter engineer, systems development department, Bell Telephone Laboratories, Inc., New York, N. Y., has been appointed telegraph development engineer.

W. E. Mitchell (A '06, F '22) president, Georgia Power Company, Atlanta, has retired. Associated with the Alabama Power Company since 1912, Mr. Mitchell joined the Georgia Company in 1927 as vice-president and general manager. He was elected president in 1945. He was AIEE vice-president for 1925–27.

OBITUARY

Hammond Vinton Hayes (A '89, F '13) retired chief engineer of the American Telephone and Telegraph Company, who pio-

neer most of the fundamentals of the modern telephone system, and former president of the Submarine Signal Corporation, died March 22, 1947, in Boston, Mass., where he maintained a private research laboratory. Born in Madison, Wis., August 28, 1860, Mr. Hayes was graduated from the Boston Latin School and received the bachelor of arts degree from Harvard College in 1883. In 1885 he was graduated from Massachusetts Institute of Technology and was awarded the degrees of master of arts and doctor of philosophy by Harvard University. He joined the American Bell Telephone Company, Boston, in 1885, as head of the mechanical department. He later was named electrical engineer and assistant chief engineer. When the American Bell Company, which had been the parent company of the Bell System, was absorbed by the American Telephone and Telegraph Company in 1902, Mr. Hayes was appointed to a 3-man committee which directed the development and research activities of the combined companies. The committee was dissolved in 1905, and Mr. Hayes became chief engineer. In 1907 when the company's engineering activities were transferred to New York, N. Y., he resigned and was titled consulting engineer. The years from 1885 to 1907 saw many revolutionary changes in telephony, for the adoption, recognition, or installation of which Mr. Hayes was responsible as chief of developmental activities, and he himself was credited with 20 patents during these years. Among the improvements incorporated into the telephone system in this period were: employment of transpositions to reduce cross talk in 1886; the beginnings of paper-insulated cable; the solid-back transmitter (1890); the common battery switchboard (1893); 4-party full-selective ringing; interrupted a-c ringing; commercial development of loading; development and application of phantom circuits; use of the first repeater (between New York and Pittsburgh); initiation of extensive development on automatic switching systems; and development of methods for protecting telephone lines from lightning and other high-voltage disturbances. He was president of the Submarine Signal Corporation from 1925 to 1930. Mr. Hayes was the author of "Public Utilities—Their Cost New and Depreciation" and "Public Utilities—Their Fair Present Value and Return." He was a fellow of the American Academy of Arts and Sciences, and a member of the Institute of Radio Engineers and the Acoustical Society of America.

Arthur Casson Hobble (A '03, M '12) consulting engineer, El Paso, Tex., who until 1939 was technical director and chief engineer of the Ebro Irrigation and Power Company, Barcelona, Spain, died March 25, 1947. Mr. Hobble was born in Glasford, Ill., January 9, 1880, and was graduated from the University of Illinois with the degree of bachelor of science in electrical engineering in 1901. In 1910 he returned to the university to receive the degrees of master of science and electrical engineer. After a period in the testing and switchboard drafting departments of the General Electric Company, Schenectady, N. Y., he was sent to Mysore State, Southern India, in 1903 to engage in hydroelectric construction, operation, and management on the Cauvery Power Scheme. In 1911 he joined the Mexican Northern Power Company, Santa Rosalia, Chihuahua, as chief electrical engineer on construction. When civil war suspended construction in 1914, he spent a year as editor for the Chicago Chamber of Commerce, working on smoke abatement and electrification of railway terminals. Recalled to Mexico in 1915, he completed the construction program and remained as chief electrical engineer until a fresh outbreak of civil war closed down the system in 1916. Mr. Hobble then became first assistant to the chief engineer of the Ebro Irrigation and Power Company and chief engineer in 1918. He was made technical director as well of all the consolidated companies forming the Union Electrica de Catuluna in 1925. Mr. Hobble returned to the United States in 1939.

George R. Benjamin (A '07) retired engineer of automatics, Western Union Telegraph Company, died April 28, 1947, in Jersey City, N. J. Mr. Benjamin was born in Hartford, Conn., November 25, 1873. He entered the employ of the Western Union Company, New York, N. Y., in 1888 as an office messenger and a year later became a telegraph operator. In 1913 he was titled engineer of automatics and started work on the company's multiple system used on most long-distance lines. Between 1920 and 1925 he was associated with the development of the teleprinter. Among the inventions for which Mr. Benjamin was responsible, or in which he co-operated, are the Barclay System, automatic ticker transmission, high speed ticker and nation-wide stock ticker systems, cable code transmitter, ocean cable multiplier, regenerative repeaters, cable amplifiers, teleprinter perforators, Varioplex system, multiplex extended channels, storing transmitters and reperforators used in the major leased-wire systems. At his retirement in 1941, a company officer said that Mr. Benjamin, more than any other engineer, was responsible for the development of high-speed telegraph apparatus which resulted in the shift from Morse to automatic communications methods.

Harry W. Deininger (A '12, M '25) vice-president, Iowa Southern Utilities Company, Centerville, died April 18, 1947. Born September 8, 1884, in Pekin, Ill., Mr. Deininger attended Armour Institute of Technology. He commenced his career as an electrician for Charles A. Stevens and Brothers in 1905 and master mechanic for Corn Products Refining Company in 1906. He was employed as an engineer by the Jefferson (Iowa) Electric Company in 1908. In 1910 he joined the Sac City (Iowa) Electric Company as general manager and became district manager of the Iowa Light, Heat and Power Company, Sac City, in 1914. His association with the Iowa Southern Company dated from 1918 when he was was made general superintendent. He was appointed assistant general manager in 1920 and vice-president in 1937. Mr. Deininger was a member of the Iowa Engineering Society.

Tracey Dickey Waring (A '06, M '13) consulting electrical engineer, Standard Underground Cable Company, of Pittsburgh, Pa., and Hamilton, Ontario, Canada, died April 27, 1947. Born in Pittsburgh, March 23, 1873, Mr. Waring attended New College, Eastbourne, England; Collége International, Geneva, Switzerland; and the Königliche Technische Hochschulé, Hanover, Germany. He had been associated with the Underground Cable Company, founded by his father in 1881, since 1896. He was superintendent for the company at Perth Amboy, N. J., until 1922, at which time he became manager of the manufacturing department, Hamilton. In 1935 he moved to Toronto, Ontario, as consulting engineer. He was a member of the Royal Astronomical Society of Toronto.

Robert Rusaw Richey (A '43) sales engineer, Westinghouse Electric Corporation, San Diego, Calif., died March 31, 1947. Mr. Richey, who was born October 15, 1901, in Merced, Calif., received the degree of bachelor of arts from the University of California in 1924. After graduation he entered the student training course of the Westinghouse Corporation in Pittsburgh, Pa. He was transferred to the central station division, San Francisco, Calif., office in 1925 and to Fresno, Calif., in 1937. He had been at San Diego since 1942 as acting manager. He was chairman of the AIEE San Diego Section for 1945–46. Mr. Richey also was a member of the San Diego Electrical Club, the Pacific Coast Electrical Association, and the Technical and Scientific Societies Council of San Diego.

Robert E. Lowe (A '34, M '44) manager, central station department, General Electric Company, Newark, N. J., died December 15, 1946. Mr. Lowe, who was born in Brooklyn, N. Y., March 3, 1893, was graduated from Ohio Northern University in 1915 with the degree of electrical engineer. After a year with the Union Switch and Signal Company, he joined the General Electric Company, Pittsfield, Mass., in 1917. He was transferred to the New York, N. Y., office as transformer specialist in 1919 and became central station general application engineer in 1929. In 1939 he was placed in charge of the central station department of the Newark office. He was a member of the New York Society of Professional Engineers.

Otto Martin Rau (A '03, M '06) retired consulting engineer, Miami, Fla., died April 3, 1947. Mr. Rau was born in New York, N. Y., May 21, 1869, and attended Cooper Union. He first was associated with the Edison General Electric Company of New York and then with the General Electric Company. He had been superintendent and chief electrician for the Milwaukee (Wis.) Electric Light and Railway Company. In later years he held the positions of general manager of the Commonwealth Power Company, Milwaukee; power specialist for the Stotesbury Mitten Management; assistant to the president of Day and Zimmerman; engineer for the Public Service Commission of Pennsylvania; and consulting engineer for the New York Power Authority. He went to Miami in 1937.

Russell Van Sanford (M '31) superintendent of electrical distribution, Tucson (Ariz.) Gas, Electric Light and Power Company, died February 14, 1947. Mr. Van Sanford was born October 5, 1892, in Detroit, Mich., and received the degree of bachelor of science in electrical engineering from the University of Michigan in 1915. He joined the Tucson Company in 1918 and was appointed superintendent of electrical distribution in 1926. In 1945 he was cited by the Secretary of War for his efforts in designing and installing electric systems supplying war industries in the Tucson area. He had served on the AIEE power transmission and distribution committee and was a member of the Tucson Engineering Club.

Karl Carson Mason (A '19) general superintendent, Brockton (Mass.) Edison Company, died March 16, 1947. Mr. Mason was born in Keane, N. H., September 1, 1891, and was graduated from Massachusetts Institute of Technology in 1914. He joined the Brockton Company as a switchboard operator and in 1916 was named assistant electrical engineer, becoming electrical engineer in 1920. From 1923 to 1925 he was superintendent of light and power for the Nova Scotia Tramways and Power Company, Ltd., Halifax, Canada, and in 1925 became assistant plant superintendent at Brockton. He was made superintendent of production in 1927 and general superintendent in 1932.

Richard Paul Buchman (A '38) assistant vice-president, Ohio Bell Telephone Company, Cleveland, died March 24, 1947. Mr. Buchman was born September 20, 1901, in Canton, Ohio, and was graduated from Case School of Applied Science in 1924. He joined the Ohio Bell Company in Canton, as engineer in 1924 and the next year was made installation supervisor. In 1926 he was transferred to Cleveland as plant supervisor, and in 1928 to Columbus, Ohio, as general plant superintendent. He was appointed assistant to the vice-president in 1937 and assistant vice-president in 1939.

MEMBERSHIP • •

Recommended for Transfer

The board of examiners, at its meeting of April 17, 1947, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the secretary of the Institute.

To Grade of Fellow

Berkner, L. V., executive secretary, Joint Research and Development Board, Washington, D. C.
Carville, T. E. M., mgr., industrial engg. dept., Westinghouse Elec. Corp., Lima, Ohio.
Hall, W. B., prof. of elec. engg.; head, dept. elec. engg., Rhode Island State College, Kingston, R. I.
Hester, E. A., mgr., planning & dev. dept., Duquesne Lt. Co., Pittsburgh, Pa.
Miller, J. L., chief engineer, equipment & telecommunications, British Insulated Callender's Cables, Ltd., Prescot, Lanc., England.

5 to grade of Fellow

To Grade of Member

Adolphe, M. H., flight test engineer, Lockheed Aircraft Corp., Burbank, Calif.
Allen, J. F., asst. squad leader, elec. dept., Jackson & Moreland, Boston, Mass.
Allured, R. B., research associate, engg. research dept., Univ. of Michigan, Ann Arbor.
Batchelor, J. W., design engineer, Westinghouse Elec. Corp., East Pittsburgh, Pa.
Bell, R. O., application engineer-transformers, Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Blake, R. I., equipment & building engineer, Pacific Tel. & Tel. Co., San Francisco, Calif.
Cromwell, P. C., assoc. prof. of elec. engg., New York Univ., New York, N. Y.
Crow, W. A., senior engineer, elec., Union Oil Co. of California, Los Angeles, Calif.
DuChemin, N. M., works manager, General Elec. Co., West Lynn Works, Mass.
Eaton, M., elec. engineer, Shawinigan Chemicals, Ltd., Shawinigan Falls, Quebec, Ontario, Canada.
Frick, C. W., section engineer, general engg. & consulting lab., General Elec. Co., Schenectady, N. Y.
Gibson, G. P., design engineer, Westinghouse Elec. Corp., Buffalo, N. Y.
Gill, W. P., elec. engineer, War Dept., Office of Engineers, Washington, D. C.
Gorin, E., designer, Consolidated Edison Co. of N. Y., Inc., New York, N. Y.
Heinze, G. M., elec. supervisor, N. Y., N. H., & H. R. R. Co., New Haven, Conn.
Hewlett, W. R., partner, Hewlett-Packard Co., Palo Alto, Calif.
Hoffman, E. S., senior ordnance elec. engineer, Navy Dept., Bureau of Ordnance, Washington, D. C.
Howard, D. G., prof. of elec. engg., U. S. Naval Academy, elec. engg. dept., Annapolis, Md.
Isbister, E. J., research engineer, Sperry Gyroscope Co., Inc., Great Neck, N. Y.
Killgore, C. L., elec. engineer, U. S. Bureau of Reclamation, Denver, Colo.
Kyte, W. O., manager, adv. & sales promotion div., apparatus dept., General Elec. Co., Los Angeles, Calif.
Lewis, C. E., engineer, personnel, Western Elec. Co., Inc., Baltimore, Md.
Lind, L. L., Jr., asst. engineer, office elec. engr., N. Y., N. H., & H. R. R., New Haven, Conn.
Lovell, N. M., elec. supt., Tucson Gas, Elec. Lt. & Pr. Co., Tucson, Ariz.
Marshall, L. C., prof. of elec. engg.; director, microwave lab., dept. of engg., University of Calif., Berkeley.
McKie, W. M., application engineer, Canadian General Elec. Co., Toronto, Ont., Canada.
Miller, R. P., supt. & elec. engineer, Instituto DeLa Ciudad Universitaria, Caracas, Venezuela, S. A.
Moore, M. M., senior engineer, Federal Power Comm., Washington, D. C.
Nagel, F. D., federal and marine section engg. div., General Elec. Co., San Francisco, Calif.
Olson, A. G., asst. supt., water & elec. dept., Village of Winnetka, Winnetka, Ill.
Ostendorf, E. W., asst. elec. supt., Alcoa Works, Aluminum Co. of America, Alcoa, Tenn.
Reed, C. L., Jr., asst. to works engineer, General Elec. Co., Erie Works, Erie, Pa.
Relfe, D. H., elec. & mech. engineer, Port of Oakland, Oakland, Calif.
Robinson, J. W., district mgr., Leeds & Northrup Co., San Francisco, Calif.
Roche, W. A., elec. engineer, Natl. Bureau of Standards, Washington, D. C.
Rotkin, I., electronics engineer, Natl. Bureau of Standards, Washington, D. C.
Schonhoff, J. A., asst. chief elec. engineer, The Maryland Drydock Co., Baltimore, Md.
Shaffer, E. C., telecommunications engineer, U. S. Govt., dept. of commerce, Washington, D. C.
Smedberg, M. W., regional construction engineer, Rural Electrification Adm., Washington, D. C.
Smith, R. B., test engineer, I-T-E Circuit Breaker Co., Phila., Pa.
Spreen, H. F., distribution supervisor, Texas Elec. Service Co., Fort Worth, Tex.
Stanhope, H. W. P., elec. engineer, J. G. White Engg. Corp., New York, N. Y.
Thompson, W. B., chief elec. engineer, Firestone Tire & Rubber Co., Memphis, Tenn.
Tietze, M. W., elec. application engineer, Harnischfager Corp., Milwaukee, Wis.
Triplett, P., assistant engineer, Allis-Chalmers Mfg. Co., rectifier engg. section, West Allis, Wis.
Trommer, C. H., asst. elec. engineer, Public Utility Engr. & Service Corp., Chicago, Ill.
Ulm, L. G., division construction supt., The Ohio Bell Tel. Co., Dayton, Ohio.
Weppler, H. E., radio engineer, Michigan Bell Tel. Co., Detroit, Mich.
West, L. G., foreman, gunsight modification dept., A-C Spark Plug, Flint, Mich.

49 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the secretary before June 21, 1947, or August 21, 1947, if the applicant resides outside of the United States or Canada.

To Grade of Fellow

Muller, H. N., (re-election), Muller & Harper, Pittsburgh, Pa.
Oliver, A. J., The Ohio Bell Tel. Co., Cleveland, Ohio.

2 to grade of Fellow

To Grade of Member

Ackely, F. E., General Elec. Co., Schenectady, N. Y.
Adams, H. J., 101 Cardinal Ave., Alamo Hts., San Antonio, Tex.
Anderson, T. R., U. S. Bureau of Reclamation, Coulee Dam, Wash.
Bennet, W. L., LaGuardia Field, Jackson Heights, L. I., N. Y.
Burchell, H. G., Comdr. (L), RCN, Natl. Defense Hdqtrs., Ottawa, Ontario, Canada.
Cohan, T. R., Abbey Elec. Co., Chicago, Ill.
Cone, W. B., Shevlin Hixon Co., Bend, Oreg.
Cornely, E. P., The Eastern Specialty Co., Philadelphia, Pa.
Dunkle, W. F., Pennsylvania Pr. & Lt. Co., Hazleton, Pa.
Graham, A. H., General Elec. Co., Erie, Pa.
Harris, W. C., General Elec. Co., Erie, Pa.
Higgs, W. F., Higgs Motors Ltd., Witton, Birmingham, England.
Hole, F. C., County of London Elec. Supply Co. Ltd., London, England.
Hubbell, H. O., Rural Elec. Adm., Washington, D. C.
Hunt, E. V., Canadian General Elec. Co. Ltd., Toronto, Ontario, Canada.
Jordan, R. J., Pirelli General Cable Works, Ltd., Southampton, Hants, England.
Knighton, D. W. R., Bengal Nagpur Railway, Khargpur, Bengal, India.
Langlois-Berthelot, R., Electricite de France, Paris, France.
Lawrence, C. B., Riverside Steel Co., Wheeling, W. Va.
Lawrence, S. N., Canadian General Elec. Co., Ltd., Toronto, Ontario, Canada.
Lingo, C. K., Florida Pr. & Lt. Co., Miami, Fla.
Middleton, H., Zinc Corp. Ltd., Broken Hill, Australia.
Morrow, W. P., E. I. DuPont de Nemours & Co., Wilmington, Del.
Plumlee, C. H., Navy Dept., Bureau of Yards & Docks, Washington, D. C.
Ragsdale, I. V., Tennessee Valley Authority, Chattanooga, Tenn.
Rizzo, J. G., Westinghouse Elec. Intl. Co., New York, N. Y.
Simpson, S. H., Jr., RCA Communications, Inc., New York, N. Y.
Smoyer, C. A., E. I. DuPont de Nemours & Co., Wilmington, Del.
Tasee, Y. R., Canadian General Elec. Co., Ltd., Quebec City, Quebec, Canada.
Thomas, H. C., General Elec. Co., West Lynn, Mass.
Thorson, H. L., General Elec. Co., Schenectady, N. Y.
Tracy, E. H., Canadian General Elec. Co. Ltd., Toronto, Ontario, Canada.
Van Fleet, G. L., 1414B North Robinson, Oklahoma City, Okla.
Watson, P. S., Beds, Cambs & Hunts Electricity Co., St. Neots, Hunts, England.

Yao, Y. Y., Wha Tung Elec. & Gen. Engg. Works, Shanghai, China.
Yingling, G. L., Jr., A. M. C., Wright Field, Dayton, Ohio.

36 to grade of Member

To Grade of Associate

United States, Canada and Mexico

1. North Eastern

Bauman, N. C., New York Tel. Co., Buffalo, N. Y.
Beers, G. M., United Illuminating Co., New Haven, Conn.
Foley, J. J., General Elec. Co., Pittsfield, Mass.
Fox, M., Lapointe Machine Tool Co., Hudson, Mass.
Garce's, H., General Elec. Co., Schenectady, N. Y.
Giles, R. P., General Elec. Co., Schenectady, N. Y.
Hardy, E. D., Town of Ipswich Lt. Dept., Ipswich, Mass.
Harris, D. J., Sherry Radio, Hartford, Conn.
Hawkins, J. E., The Conn. Pr. Co., Stamford.
Holden, R. A., Vermont Hardware Co., Inc., Burlington, Vt.
Hollyday, J. S., Central Hudson Gas & Elec. Corp., Poughkeepsie, N. Y.
Ierardi, D. P., New England Pr. Service Co., Boston, Mass.
Ives, M. E., General Elec. Co., Pittsfield, Mass.
Lawson, E. R., IBM, Corp., Endicott, N. Y.
Lule, M. J., Westinghouse Elec. Corp., Buffalo, N. Y.
McMillan, E. C., IBM, Corp., Endicott, N. Y.
Murray, L. A., Jr., U. S. Rubber Co., Providence, R. I.
Noyes, R. A., IBM, Corp., Endicott, N. Y.
Peltosalo, A. E., General Elec. Co., West Lynn, Mass.
Pfeif, R. E., General Elec. Co., Worcester, Mass.
Plummer, W. E., General Elec. Co., Schenectady, N. Y.
Posluszny, A. G., Westinghouse Elec. Co., Checktowaga, N. Y.
Rose, E., IBM Corp., Endicott, N. Y.
Shaw, F. D., General Elec. Co., Boston, Mass.
Terry, S. M., General Elec. Co., Lynn, Mass.
Ubaldi, C., Chase Brass & Copper Co., Waterbury, Conn.
Vilbig, J. L., Jr., General Elec. Co., Schenectady, N. Y.
Wood, R. B., Eastman Kodak Co., Rochester, N. Y.

2. Middle Eastern

Abraham, G., Naval Research Lab., Washington, D. C.
Bachman, R. J., Western Elec. Co., Baltimore, Md.
Christian, D. R., The Brush Development Co., Cleveland, Ohio.
Corey, F. C., The Hoover Co., North Canton, Ohio.
Crump, R. F., Virginian Ry. Co., Princeton, W. Va.
Douville, F. W., Permanente Metals Corp., Mead, Wash.
Flagg, L. F. (re-election), Minneapolis-Honeywell Regulator Co., Washington, D. C.
Forman, R. J., Jr., Delaware Pr. & Lt. Co., Wilmington, Del.
Lahn, F. C., AMC, Wright Field, Dayton, Ohio.
Nugent, J. W., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Propst, R. F., General Elec. Co., Philadelphia, Pa.
Randles, F., Jr., The Glenn L. Martin Co., Baltimore, Md.
Schneider, A. G., Duquesne Lt. Co., McKeesport, Pa.
Solis, F. R., Philadelphia Elec. Co., Philadelphia, Pa.
Spanich, E., AMC, Wright Field, Dayton, Ohio.
Strasser, R. A., AMC, TSEPF-10, Wright Field, Dayton, Ohio.
Vath, D. L., General Elec. Co., Philadelphia, Pa.
Wallace, B. W. (re-election), The Toledo Edison Co., Ohio.
White, A. C., Federal Pr. Comm., Washington, D. C.
Wilson, L. A., Bonneville Pr. Adm., Pittsburgh, Pa.
Yost, C. F., Johns Hopkins Applied Physics Lab., Silver Spring, Md.
Zand, D., Potomac Elec. Pr. Co., Washington, D. C.
Zeigler, N. L., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Zimmerman, G. H., G. H. Zimmerman Co., Charleston, W. Va.

3. New York City

Anselm, W. F., Intl. General Elec. Co., New York, N. Y.
Chen, C. L., China Elec. Co. c/o Federal Tel. & Radio Corp., Clifton, N. J.
Farmer, W. M. (re-election), Ebasco Services, Inc., New York, N. Y.
Franklin, R. M., Sperry Gyroscope Co., Inc., Great Neck, N. Y.
Garig, H. H., Standard Oil Co., N. J., New York, N. Y.
Gorczycki, E., Western Elec. Co., Newark, N. J.
Green, A., Allen B. Du Mont Labs. Inc., Passaic, N. J.
Infantino, J., Westinghouse Elec. Corp., Newark, N. J.
Johnson, C. N., Ebasco Services, Inc., New York, N. Y.
Johnson, W. V., Welton V. Johnson Engg. Co., Summit, N. J.
Kaplan, M. B., Signal Corps Engg. Labs., Belmar, N. J.
Kochli, E. G., American Molasses Co., Brooklyn, N. Y.
Lange, R. F., N. Y. Central System, New York, N. Y.
Logan, G. F. (re-election), 59 94th Street, Brooklyn, N. Y.
Mendelsohn, J., Anaconda Copper Co., New York, N. Y.
Morrow, G. Board of Transportation, New York N. Y.
Porter, R. K., Consolidated Edison Co., New York, N. Y.
Proper, W. E., Veterans Adm., New York, N. Y.
Richford, J. E., Veterans Adm. Hospital, Northport, New York.
Rothschild, R. S., J. S. Hamel, New York, N. Y.
Sherman, J., Westinghouse Elec. Corp., Newark, N. J.
Sitzer, I., 337 Grafton St., Brooklyn, N. Y.
Stevenson, R. F., American Airlines, Inc., Flushing, N. Y.
Wuehrmann, J. B., Standard Oil Development Co., Elizabeth, N. J.

4. Southern

Boone, W. A., Alabama Pr. Co., Birmingham, Ala.
Elissalde, M. H., Gulf States Utilities Co., Baton Rouge, La.
Franks, G. W., The Engineer Board, Fort Belvoir, Va.
Grove, L. Y., Box 866, Va. Tech. Station, Blacksburg, Va.
Hallmark, G. D., Clemson College, Clemson, S. C.
Knauss, A. R., Allis-Chalmers Mfg. Co., Memphis, Tenn.
Leaf, P. M., Western Elec. Company, Winston-Salem, N. C.
Long, L. W., N. C. State College, Raleigh, N. C.
Malone, J. L., White Elec. Const. Co., Columbus, Ga.
Mary, A. J. (re-election), Gulf States Utilities Co., Baton Rouge, La.
Matthews, W. W., Matthews Elec. Supply Co., Lake Charles, La.
Motley, C. C., Tennessee Valley Authority, Knoxville, Tenn.
Quinby, T. R., Quinby Elec. Co., Tampa, Fla.
Ramon, J. C., Jr., New Orleans Public Service, Inc., New Orleans, La.
Rhinesmith, L. E., Transportation School, Ft. Eustis, Va.
Sheffer, J. E., Jr., Scott S. Huff Elec. Co., Arlington, Va.
Snow, P. L., Bryant Elec. Co., High Point, N. C.
Thibaut, A. A., Jr., Knoxville Utilities Board, Knoxville, Tenn.
Wade, A. C., Alabama Pr. Co., Birmingham, Ala.

5. Great Lakes

Alexander, E. C., Illinois Bell Tel. Co., Chicago, Ill.
Anderson, E. A., Public Utility Engg. & Service Corp., Chicago, Ill.
Bjerke, H. F., GMC, Electro-Motive Div., La Grange, Ill.
Boesenberg, E. H., Public Service Co. of No. Ill., Streator, Ill.
Borek, J. J., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Braswell, Z. T., Square D Co., Milwaukee, Wis.
Burke, C. J., Detroit Edison Co., Detroit, Mich.
Callentine, C. L., GMC, Electro-Motive Div., La Grange, Ill.
Campbell, D., Univ. of Iowa, Iowa City.
Clark, J. R., Jr., Purdue Univ., Lafayette, Ind.
Cohan, B. M., Western Elec. Co., Chicago, Ill.
Cole, D., Public Service Co. of No. Ill., Chicago, Ill.
Dermer, R. D., Indiana Technical College, Ft. Wayne, Ind.
Ehmke, H. C. (re-election), Deere & Co., Waterloo, Iowa.
Evans, J. M., American Wheelabrator & Equip. Corp., Mishawaka, Ind.
Everts, H. H., Ft. D. D. M. & So. Ry. Co., Boone, Iowa
Jay, J., Commonwealth Edison Co., Chicago, Ill.
Johnson, B. C., Iowa State College, Ames.
Kettering, O. L., South Bend Elec. Co., Inc., South Bend, Ind.
Martin, W. L., National Malleable & Steel Castings Co., Melrose, Ill.
McCormick, J. S., Western Elec. Co., Chicago, Ill.
Patterson, C. E., Ford Motor Co., Dearborn, Mich.
Pirhofer, D. J. J., Perfex Corp., Milwaukee, Wis.
Raiter, S. J., P. R. Mallory & Co., Inc., Indianapolis, Ind.
Ritter, J. H., (re-election), Buick Motor Co., Flint, Mich.
Ryden, S. W., Illinois Bell Tel. Co., Chicago, Ill.
Schultz, H. W., Northwestern Tech. Inst., Evanston, Ill.
Shoemaker, T. M., Iowa-Illinois Gas & Elec. Co., Rock Island, Ill.
Smith, W., Western Elec. Co., Cicero, Ill.
VanLaanen, L. V., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Vines, J. N., Iowa Pr. & Lt. Co., Des Moines, Iowa.

6. North Central

Pendill, R. D., Arvada Elec. Co., Arvada, Colo.
Sweany, F. H., (re-election), U. S. Bureau of Reclamation, Denver, Colo.

7. South West

Abright, William F., Dow Chemical Co., Freeport, Tex.
Bickley, E. C., Univ. of New Mexico, Albuquerque, N. M.
Carnes, E. C., Sverdrup & Parcel, St. Louis, Mo.
Eads, R., Jr., Lynn Elliott Co., Houston, Tex.
Esler, William R., Lower Colorado River Authority, Austin, Tex.
Harding, G. C., TWA, Inc., Kansas City, Mo.
Lohman, I. H., Jr., Emerson Elec. Mfg. Co., St. Louis, Mo.
MacDowell, R. E., Wetherbee Elec. Co., Oklahoma City, Okla.
Moore, R. A., P. O. Box 265, Brackettville, Tex.
Pearson, W. L., Southwestern Public Service Co., Slaton, Tex.
Rich, H. M., Phil-Rich Mfg. Co., Houston, Tex.
Sabin, R. J., Physical Science Lab., State College, Las Cruces, N. M.
Sellman, R. A., Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Sheppard, H. R., Univ. of Kansas, Lawrence.
Standish, T. A., Houston Lighting & Pr. Co., Houston, Tex.
Thomas, F. L., Jr., A & M College of Texas, College Station, Tex.
Windecker, R. T., U. S. Navy, NATTC, Ward Island, Corpus Christi, Tex.

8. Pacific

Anchordoguy, A. R., Pacific Gas & Elec. Co., Oakland, Calif.
Anders, E. O., Fluorescent Fixtures of Calif., San Francisco, Calif.
Banning, W. B., Dept. of Water & Pr., Los Angeles, Calif.
Bockmier, G. E., Underwriters Laboratories, San Francisco, Calif.
Cannell, H. P., Solar Aircraft Co., San Diego, Calif.
Colony, M. P. (re-election), Sacramento Municipal Utility District, Sacramento, Calif.
DeWolfe, N. C., Pacific Tel. & Tel. Co., San Francisco, Calif.
Drake, J. H., California Inst. of Tech., Pasadena.
Elliott, L. C., Pacific Gas & Elec. Co., San Francisco, Calif.
Gardner, D. M., Los Angeles Dept. of Water & Pr., Los Angeles, Calif.
Geiger, F. J. E., War Dept., Corps of Engrs., Los Angeles, Calif.
Haber, K. H., Pacific Tel. & Tel. Co., San Francisco, Calif.
Latrop, E. V., Pacific Gas & Elec. Co., Redding, Calif.
Miller, M. J., Standard Oil Co. of Calif., San Francisco, Calif.
Pitts, R. M., U. S. Elec. Motors, Los Angeles, Calif.
Rawson, R. R., Westinghouse Elec. Corp., San Francisco, Calif.
Sodaro, R. M., Hazeltine Research Inc. of Calif., Los Angeles, Calif.
Warmoth, H. W., Sacramento Municipal Utility District, Sacramento, Calif.
Wells, E. A., Pacific Tel. & Tel. Co., San Francisco, Calif.
Whitney, W. G. (re-election) Pacific Gas & Elec. Co., Chico, Calif.
Worthington, A. R., Pacific Gas & Elec. Co., San Francisco, Calif.

9. North West

Bryan, N., Jr., Boeing Aircraft Co., Seattle, Wash.
Cumming, M. L., Hanford Engineer Works, Richland, Wash.
Drysdale, W. C., 757 East Milton Ave., Provo, Utah.
Harrington, E. J., Bonneville Pr. Adm., Portland, Oreg.
Hoffman, E. H., Bonneville Pr. Adm., Spokane, Wash.
Johnson, H. S., Portland General Elec. Co., Portland, Oreg.
Opdenweyer, A. E., Portland General Elec. Co., Portland, Oreg.
Pluhar, E. W., Modern Equipment Co., Great Falls, Mont.
Simonds, R. H., Jr., Western Washington College, Bellingham, Wash.

10. Canada

Black, F., Schlumberger Well Surveying Corp., Calgary, Alberta, Canada
Brown, F. W., Geo-Tech. Development Co., Ltd., Bourlamaque, Quebec, Canada
Cassidy, E. B., Canadian General Elec. Co., Ottawa, Ontario, Canada
Lee, J. W., Hydro-Elec. Pr. Comm. of Ontario, Niagara Falls, Ontario, Canada
Legeer, R. J., Lt., R.C.N., Halifax, Nova Scotia, Canada
Marks, W. H., B. C. Pr. Comm., Nanaimo, British Columbia, Canada
Strachan, J. L., Natl. Research Council, Chalk River, Ontario, Canada
Wait, P. A., Thomson Elec. Works Ltd., Montreal, Quebec, Canada

Elsewhere

Halldorsson, S. G., Univ. of Iceland, Reykjavik, Iceland
Chou, J. S., Chinese Natl. Resources Comm., Shanghai, China
Lyon, G., Associated Elec. Industries, London, England

Total to grade of Associate
United States, Canada and Mexico, 183
Elsewhere, 3

OF CURRENT INTEREST

Judges and Program for Lighting Exposition Announced

Judges have been announced for the competition sponsored by the Second International Lighting Exposition and Conference to be held in Chicago, Ill., November 3–7, 1947, under the sponsorship of the industrial and commercial lighting equipment section of the National Electrical Manufacturers Association (*EE, Mar '47, p 314*). The judges are: Carl Zersen, Chicago (Ill.) Lighting Institute; Marshall Waterman, Electrical Testing Laboratories, Inc., Chicago, Ill.; C. J. Martin, publisher, *Electrified Industry*, Chicago, Ill.; W. T. Stuart (A '43) editor, *Electrical Contracting*, New York, N. Y.; and Professor J. O. Kraehenbuehl, University of Illinois, Urbana.

Basis for judging entries will be primarily by their merit in terms of customer benefits shown. Decision of the judges will be final, and all entries, dead line for which is August 31, 1947, will become the property of the International Lighting Exposition. Outstanding entries will be displayed at the exhibition in the Stevens Hotel. Further details and entry blanks may be obtained by writing: Merit Award Committee, 326 West Madison Street, Room 818, Chicago 6, Ill.

The conference program is designed to make better known the practical applications of the newest developments in illumination, and the importance of the exhibition theme "Plan tomorrow's lighting today." The conference program includes sessions on trends and progress in lighting, industry plans for lighting promotion, how the electrical wholesaler can increase lighting sales, and the electrical contractor, the key man in the lighting plan. Over 80 leading lamp and lighting equipment manufacturers, and makers of other products which are directly related to planned lighting are scheduled to have exhibits at the Stevens Hotel.

In response to the expressed wish of many exhibitors and others interested in the exposition, official seal stamps have been printed which are available in sheets of 50 for $2.50 per 500 or $4.00 per 1,000 for use on envelopes and letterheads. Users of Pitney-Bowes postage meters may obtain standard meter advertising plates concerning the exposition.

Multijet Bomber Announced. The United States Army Air Forces has announced completion of the largest multijet bomber of conventional design ever built, the Glenn L. Martin *XB-48*, powered with six General Electric aircraft gas turbines. Because the wings are thinner than those of an airplane built for slower speed, there is not sufficient space to house the large main wheels required for safe landing and takeoff. In the *XB-48* two main wheels are placed bicycle style in the center of the ship and retract upward into the fuselage. Smaller wheels located near each wing tip to give stability during taxi operations retract into shallow wells in the wings.

Tennessee Valley Power Association Formed. The Tennessee Valley Public Power Association was formed recently in Chattanooga, Tenn., by 138 publicly owned power systems and rural co-operatives in the valley. The action was considered as a significant step in providing financial, sales promotion, accounting, managerial, and technical information for public power systems. N. R. Sinley, general superintendent of the Electrical Power Board of Chattanooga, was elected first president of the association.

Federal Trade Commission Reports on Copper Scarcity

The blame for the world wide copper shortage, and the possibility of a copper-buying "panic" in the near future, is laid at the feet of six men, four of them heads of American corporations, by the Federal Trade Commission in a report submitted to Congress recently.

"The copper situation is particularly serious, not only because of the concentration of control of the world reserves in a productive capacity, but also because the domestic supply is inadequate to meet the demands of high level national production and employment. Furthermore the production of foreign copper, on which the United States will become increasingly dependent, is likewise dominated by a few corporate groups which in the past have operated co-operatively in cartels to regulate production in prices. It would appear that dominant producers might well consider it to their advantage to permit the continuance of labor difficulties to curtail production, at least until such time as the large stock pile might be drawn down," the report states.

Boulder Dam Renamed. Boulder Dam on the Colorado River, which originally was named Hoover Dam in 1930, and later rechristened Boulder Dam in 1933, again will bear the name of the man who gave much time and energy to the Colorado River Compact without which there could have been no division of the waters between the upper and lower basins, and hence no dam. In addition, the structure is not located in Boulder Canyon, but in Black Canyon, 20 miles away. The new change was made by Congress.

New Pyrometer. An improved pyrometer for measuring high-temperature high-velocity gas streams has been developed by Andrew I. Dahl at the National Bureau of Standards, Washington, D. C., in conjunction with the Bureau of Ships, Navy Department. The main problem

Motor-Generator Set Shipped Assembled

In order to maintain lineup at the shaft of 0.001 inch, this motor-generator set had to be shipped assembled from the Fort Wayne, Ind., works of General Electric Company. The set, to be used with a large dragline excavator, has a self-supporting base 36 inches deep and 33 feet long, which carries the 65,000 pounds of the complete unit. A 900-horsepower 1,800-rpm synchronous motor drives two 190-kw d-c drag generators, two 190-kw d-c hoist generators, a 112.5-kw d-c swing generator, and a 40-kw thermal magnetic shunt exciter

in measuring the temperature of hot gases is preventing the transfer of heat to or from the thermocouple junction by radiation. Shields formerly used for this purpose have not been too successful, but a small, light, silver shield in the new instrument overcomes previous limitations. The new device was reported accurate within five degrees Fahrenheit in experiments utilizing a stream of gas at 1,500 degrees Fahrenheit flowing with a velocity of 250 feet per second through a pipe with walls at 1,200 degrees. Several have been sent to commercial turbine manufacturers for service tests in full-scale operating turbines.

Teleran Advances Demonstrated. The system of television-radar air navigation and traffic control under development by the Radio Corporation of America, Camden, N. J., has been advanced by the introduction of a new "storage orthicon" television pickup tube, a picture tube employing high intensity phosphors for greater image brilliance, an optical map-mixing technique which improves the composite image and simplifies insertion of additional information when required, and a time multiplexing system which provides for the simultaneous transmission of images representing different altitude layers and selective reception of the proper image by planes in any one of these layers. These advances were shown recently at a demonstration which simulated an aircraft course approaching National Airport in Washington, D. C. The first civilian airport installations of ground surveillance radar, which will comprise one of the basic units of the Teleran system, are planned by the Civil Aeronautics Authority in the near future at both LaGuardia Airport, New York, N. Y., and National Airport, Washington, D. C.

OTHER SOCIETIES

Army Signal Association Holds National Convention

The first annual national convention of the Army Signal Association (*EE, April '47, p 416*), of which Brigadier General David Sarnoff (M '28) president of Radio Corporation of America, is president, was held at Fort Monmouth, N. J. and New York, N. Y., on April 28 and 29, 1947.

The Army Signal Association is an organization designed to effect co-operative contact between active members of the Signal Corps of the Army, the communication services of the Ground and Air Forces, former personnel of these services, and members of American industry concerned with communications, electronics, and photography.

At a dinner meeting in New York, General Sarnoff presented honorary membership in the association to Major General Harry C. Ingles, retiring chief signal officer of the Army. Others present were Major General Joseph O. Mauborgne, a former chief signal officer; and Brigadier General Carroll O. Bickelhaupt (F '28) vice-president of the American Telephone and Telegraph Company and president of the New York chapter of the association. The principal address was delivered by Lieutenant General J. Lawton Collins, chief of public information of the United States Army, who stressed the importance of air power, of unity of command, and of signal communication.

ASA Releases Electrical Standards. A new standard, "Basic Graphical Symbols for Electrical Apparatus," known as American Standard *Z32.12* and sponsored by the AIEE and the American Society of Mechanical Engineers, is now ready for distribution according to P. G. Agnew (M '19) vice-president of the American Standards Association. The standard provides 152 basic symbols for electrical drawings which can be used as "building blocks" in the power, control, and communication fields. The new work, which supplements Standard *Z32.11* developed in 1944, was done by a committee under the chairmanship of W. L. Heard (A '26) of Bell Telephone Laboratories, New York, N. Y. Symbols covering the three fields have been available in separate Standards, *Z32.3*, *Z32.5*, and *Z32.10*, but the new work makes it possible to build up practically any of the symbols with new master symbol code.

New Motor Mounting Announced by NEMA

According to C. P. Potter (F '29) chairman of the National Electrical Manufacturers Association motor and generator section, a new set of standards for a universal flange, known as the NEMA *D* flange, for mounting both horizontal and vertical end-shield mounted electric motors has been developed.

The new flange was developed by a joint committee of representatives from NEMA and the National Machine Tool Builders Association which had been formed to consider the standardization of motors applied to machine tools. The committee established NEMA *D* flange dimensions for motors built in frames *203–505*, which covers ratings 1–125 horsepower, at 1,750 rpm. Four principal features, which are marked improvements over older flange mountings, are incorporated in the new flange: the flange has a male rabbet; the face of the flange is in line with the shaft shoulder; the diameter of the flange is not greater than that of the motor, except on frames *203* and *204;* and the motor mounts on the machine from the shaft side with mounting bolts going through the flange from the motor side. With this male rabbet mounting the only machining necessary on a machine frame upon which the motor fits covers an area equal to the diameter of the motor rabbet.

Future Meetings of Other Societies

American Society of Civil Engineers. Fall meeting, October 15–18, 1947, New Orleans, La.

American Society for Engineering Education. 55th annual meeting, June 17–21, 1947, Minneapolis, Minn.

American Society of Tool Engineers. 16th annual meeting and tool exhibition, March 15–19, 1948, Cleveland, Ohio.

American Society for Testing Materials. 50th annual meeting, June 16–20, 1947, Atlantic City, N. J.

American Society of Mechanical Engineers. Semi-annual meeting, June 16–20, 1947, Chicago, Ill.; fall meeting, September 1–4, 1947, Salt Lake City, Utah; annual meeting, December 1–5, 1947, Atlantic City, N. J.

American Standards Association. Annual meeting, October 21–23, 1947, New York, N. Y.

American Welding Society. Annual meeting, October 20–24, 1947, Chicago, Ill.

Association des Ingénieurs. Centenary congress and exhibition, August 30–September 13, 1947, Liége, Belgium.

Canadian Association of Professional Physicists. June 12–14, 1947, University of Western Ontario, London, Canada.

Canadian Electrical Association. 57th annual convention, June 18–20, 1947, St. Andrews, New Brunswick, Canada.

Canadian Institute of Radio Engineers. Convention, April 30–May 1, 1948, Toronto, Ontario, Canada.

CIGRE (International Conference on Large Electric High-Tension Systems). Biennial meeting, June 24–July 3, 1948, Paris, France.

Edison Electric Institute. Annual meeting, June 2–5, 1947, Atlantic City, N. J.

Electrical Manufacturers Representatives Club of New England. Trade show, June 4–6, 1947, Boston, Mass.

Exposition of Chemical Industries. 21st annual exposition, December 1–5, 1947, New York, N. Y.

Illuminating Engineering Society. Annual convention, September 15–19, 1947, New Orleans, La.

Institute of the Aeronautical Sciences. Annual meeting, August 7–8, 1947, Los Angeles, Calif.

Instrument Society of America. Second national conference, September 8–12, 1947, Chicago, Ill.

International Lighting Exposition and Conference. November 3–7, 1947, Chicago, Ill. Sponsored by National Electrical Manufacturers Association.

International Municipal Signal Association, Inc. 52d annual meeting, September 29–October 2, 1947, Grand Rapids, Mich.

National Association of Manufacturers. 52d Annual Congress of American Industry, December 3–5, 1947, New York, N. Y.

National District Heating Association. 38th annual meeting, June 24–27, 1947, Atlantic City, N. J.

National Electrical Contractors' Association. 46th annual meeting, September 8–10, 1947, San Francisco, Calif.

National Electrical Manufacturers Association. October 27–31, 1947, Atlantic City, N. J.; winter convention, March 14–18, 1948, Chicago, Ill.

National Electronics Conference. November 3–5, 1947, Chicago, Ill.

National Safety Congress and Exposition. 35th annual meeting, October 6–10, 1947, Chicago, Ill.

Pacific Chemical Exposition and Pacific Industrial Conferences. October 21–28, 1947, San Francisco, Calif.

Refrigeration Equipment Manufacturers Association. All-Industry Refrigerating and Air-Conditioning Exposition. January 26–29, 1948, Cleveland, Ohio.

Society of Automotive Engineers. Summer meeting, June 1–6, 1947, French Lick Springs, Ind.

The new standard design, which can be used in place of three former designs, confers obvious benefits on the machinery and tool builder, the motor manufacturer, and the motor user through uniformity of details, wider availability and interchangeability, quicker delivery, increased sources of supply, and a reduction in standby requirements.

Electronic Reserve Officers Form National Association

Former Navy and Marine officers representing a group of approximately 2,000, who worked out the application of radar in surface navigation and traffic control during World War II, recently announced the formation of a national Association of Electronic Reserve Officers to continue the association of experienced men in the application of electronic developments in aviation and navigation to national defense and civil transportation safety. AERO, as the group is called, has no affiliation with the armed services and contemplates none according to the announcement, but will consult informally with the armed services and private and commercial groups if it seems desirable or in the public interest.

Formation of local groups is already under way in Chicago, Ill.; Detroit, Mich.; Philadelphia, Pa.; Boston, Mass.; Seattle, Wash.; San Francisco, Calif.; St. Joseph, Mo.; Phoenix, Ariz.; Jacksonville, Fla.; Birmingham, Ala.; and Honolulu, T. H.; Headquarters of the organization are in room 2305, 90 Broad Street, New York, N. Y.

Broadcast Engineers Meet. A conference was held recently at Georgia School of Technology, Atlanta, sponsored by the Georgia School of Technology, the Georgia Association of Broadcasters, and the Atlanta section of the Institute of Radio Engineers. The various sessions included discussions on amplifiers, studio design, frequency modulation systems, television systems, and safety precautions for radio stations. An exhibit was held in conjunction with the conference at which various manufacturers showed their products.

CIGRE Meeting Concurrent With AIEE Summer Meeting

At the invitation of the Canadian National Committee of the CIGRE (International Conference on Large Electric High-Tension Systems) the international administrative council of CIGRE will meet in Montreal, Quebec, Canada, on June 11, 1947, during the AIEE summer meeting. This meeting, which will be under the chairmanship of CIGRE President Colonel Ernest Mercier, is called to consider suggestions for the technical program for the biennial CIGRE meeting to be held June 24–July 3, 1948, in Paris, France.

The technical subcommittee of CIGRE has been reorganized recently under the chairmanship of H. L. Melvin (F '31) chief consulting engineer for Ebasco Services, Inc., New York, N. Y., and is engaged in selecting United States representatives for the international study committees in preparing recommendations for the technical program of the 1948 Paris meeting. Experience gained in all parts of the world and technical papers bearing on these experiences will be reported at the Paris meeting.

Western Society of Engineers Elects Officers. W. V. Kahler (M '39) Illinois Bell Telephone Company, Chicago, has been elected president of the Western Society of Engineers for 1947–1948. T. G. LeClair (F '40) Commonwealth Edison Company, Chicago, is the retiring president. The other officers elected are: B. O. McClurg, consulting engineer, Mundie-Jensen-McClurg, first vice-president; Gustave Egloff, Universal Oil Products Company, second vice-president; and M. W. Casad, Illinois Bell Telephone Company, re-elected as treasurer. L. S. Keith and C. G. Anderson remain as secretary and assistant secretary respectively.

Electronics Conference Invites Papers for 1947

National Electronics Conference, Inc., has invited papers to be submitted for possible presentation at the 1947 National Electronics Conference to be held November 3–5 in Chicago, Ill. (*EE, May '47, pp 495* and *513*). A wide range of subjects will be included at the conference embracing research, development, and application in electronics and closely allied fields.

A special concession has been made by the AIEE whereby papers presented at the National Electronics Conference may be considered for AIEE *TRANSACTIONS* on the same basis as other papers from AIEE general meetings. All NEC papers which are candidates for Institute publication should be submitted in standard form to the secretary of the technical program committee, AIEE headquarters, 33 West 39th Street, New York 18, N. Y.; three to five copies by August 21, 1947.

INDUSTRY . . . . .

Public Power Systems Operating Summary Released

The American Public Power Association has just issued Bulletin *OP-47*, its first annual summary of operations of public power systems. Data for about 350 systems, most of which are city owned, are furnished in the 1947 report.

The report gives such pertinent information as total investment, operating revenues, taxes paid or payments in lieu of taxes, average annual kilowatt-hour consumption per residential customer, average annual bill per residential customer, power supply data, and typical electrical bills. Copies of the report may be obtained from the American Public Power Association, 1129 Vermont Avenue, N. W., Washington 5, D. C., for $2.00.

Northwest Utilities Ban Electric Heating. Because of the acute power shortage in the Northwest, caused by a lack of generating and distribution equipment, no new electric heating installations, such as space heaters, furnaces, and wall panels will be permitted before April 1, 1948, in areas served by the Portland General Electric Company and the Northwestern Electric Company, it was announced recently by company officials. Four reasons given why space heating will not be available until next year are: priority of a large number of applications now on file, shortages of wire and other equipment, an unprecedented increase in power consumption, and an obligation on the part of consumers not to overload existing equipment. Unaffected by the company's new policy are water-heating equipment, electric ranges, and other electric appliances.

Coal Burned Underground. Successful burning of coal underground, the possibilities of which were revealed recently by the United States Bureau of Mines, is regarded in several places as an important heat source which may prove of great potential value. An average of 35 to 50 per cent of the coal is left in the ground in present mining processes according to the Bureau. The heat available from such underground burning of coal might be utilized in a steam plant, a gas turbine plant, or as fuel for industrial furnaces, depending upon such important determining factors as the location of a given coal deposit in relation to the load center and the relative cost of transportation of the gas and the electric power. Gas considered suitable for the manufacture of synthetic fuels now is being produced in a burning mine in Jasper, Ala., according to the Bureau of Mines. The Alabama mine is one of the several abandoned or unmined coal deposits.

New Electric Heating Method Developed. A new method of radiant heating employing electrified ceilings, developed by the United States Rubber Company, New York, N. Y., is operating in an experimental house in Knoxville, Tenn., built by the Fonde Construction Company. The heating elements consist of conductive rubber sandwiched between two thin layers of plastic. Development of the electrified ceilings grew out of wartime research in which chemists trans-

formed rubber from an insulator to a conductor by adding high percentages of finely ground carbon black.

Preplanned Radar Installed. Radar will be incorporated in eight stratocruisers, luxury airliners being built for American Overseas Airlines by Boeing Airplane Company, Seattle, Wash. This installation is claimed to be the first preplanned radar in commercial aviation. Two antennas will be utilized, one in the nose pointing forward to detect storm areas and areas of dangerous icing, and the other, a 60-inch diameter unit in the belly, to map shorelines and to utilize ground radar beacons along the route for navigation. The airplanes are scheduled for transatlantic service late this year.

Strike Ends at Allis-Chalmers. The 328-day strike at the West Allis Works of the Allis-Chalmers Manufacturing Company ended recently when members of the United Auto Workers-Congress of Industrial Organizations local voted to return to work without a settlement. Approximately 6,500 production workers were on the job the first day after the strike, and the normal prestrike force of 11,000 is expected to be attained gradually.

British Industries Fair. Over 3,000 manufacturers exhibited a wide range of new developments and processes at the British Industries Fair held May 5–16, 1947, in London and Birmingham, England. Some interesting exhibits were included in the electronics section where a color-matching indicator, a thyratron power supply, and a turbine blade tip-clearance indicator were shown. Other electrical exhibits presented fusegear, welding equipment, recording and playback devices, infrared equipment, and many other items.

Certificates of Merit Presented

In ceremonies held April 14, 1947, at Governors Island, New York, N. Y., General Courtney H. Hodges, First Army commander, presented the President's Certificate of Merit to six prominent engineers in recognition of "outstanding fidelity and meritorious conduct in aid of the war effort, by formulating proposals on postwar industrial control measures in Germany and Japan." Shown holding their certificates are (left to right) Malcolm Pirnie, C. S. Proctor, R. E. McConnell, M. G. B. Whelpley, H. S. Rogers, and S. D. Kilpatrick

HONORS • • • • •

Hillis to Receive Chanute Medal. The Western Society of Engineers has chosen G. C. Hillis, general inspector, Western Union Telegraph Company, to receive the Octave Chanute Medal for 1946. The award was founded in 1901 by the late Octave Chanute during his term as president of the Western Society of Engineers for recognition of the best papers in engineering subjects presented before the society.

Cleveland Society Honors F. C. Crawford. At its first annual banquet the Cleveland Technical Society Council presented its Distinguished Service Award to F. C. Crawford, president of Thompson Products, Inc. Professor G. Brooks Earnest of Case School of Applied Science and council president, and C. L. Collins (M '40) chairman of the board of Reliance Electric and Engineering Company, made the award. The presentation was made to Crawford because of his outstanding contribution to the "advancement and welfare of engineering and the technical profession."

China Presents Medal to H. S. Scott. Captain Hoyt S. Scott, United States Naval Reserve, illuminating engineer for General Electric Company, Nela Park, Cleveland, Ohio, recently was awarded the Army-Navy Air Distinguished Service Medal of China "for exceptionally meritorious services as communications engineer of the Friendship Project from September 1944 until the surrender of Japan." V. K. Wellington Koo, Chinese ambassador to the United States, and United States Fleet Admiral Chester W. Nimitz were present at the award ceremonies.

Hyatt Plastics Medal to Doctor Grebe. Charles F. Kettering (F '14) vice-president of General Motors Corporation, Detroit, Mich., and member of the John Wesley Hyatt Award committee, recently presented the gold medal and $1,000 which comprise the annual award to Doctor John J. Grebe for his outstanding work in the plastics industry in 1946. Doctor Grebe is director of the Dow Chemical Company physical research laboratory at Midland, Mich., and was honored for his work in the production of pure styrene and its polymerization. The presentation is in honor of Hyatt, the father of the American plastics industry.

EDUCATION • • •

Available Fellowships Listed for 1947–48

As a service to the members of the Institute a partial list of fellowships available at various institutions throughout the United States for the coming academic year are listed. The list includes university, industrial, and private institution grants.

Battelle Memorial Institute—limited number of predoctoral fellows and postdoctoral associates; for investigation of fundamental nature in physics, chemistry, electronics, ceramics, metallurgy, and fuels and combustion; at the Battelle Memorial Institute, Columbus, Ohio.

Charles A. Coffin Foundation—annual grants to graduates; for continuation or undertaking of research in the fields of electricity, physics, and physical chemistry; in the United States or abroad. Established by General Electric Company, Schenectady, N. Y.

Eastman Kodak—12 annual grants for doctoral work, one for chemical engineering at Massachusetts Institute of Technology, Cambridge, one for organic chemistry at the University of Illinois, Urbana, one for physical chemistry at the University of Rochester (N. Y.), and the nine others—six in chemistry and three in physics—to be rotated among various universities; ten fellowships for master's work, four to design work in mechanical engineering, two in electrical engineering, and four in business administration, all to be utilized at different schools. Sponsored by Eastman Kodak Company, Rochester, N. Y.

Charles LeGeyt Fortescue—annual awards to most promising candidates; for graduate work in electrical engineering; at accredited engineering schools. Administered by AIEE committee, New York, N. Y.

Georgia School of Technology—two fellowships; for electrical engineering; at Georgia School of Technology, Atlanta. Sponsored by Westinghouse Educational Foundation, Westinghouse Electric Corporation, Pittsburgh, Pa. Also a number of fellowships for research in all phases of engineering taught at Georgia School of Technology.

Illinois Institute of Technology—one graduate fellow each year; for power systems engineering; at Illinois Institute of Technology, Chicago. Established by Westinghouse Electric Corporation Educational Foundation.

Frank B. Jewett—annual grants to men and women for postdoctorate research; in the physical sciences including chemistry, mathematics, and physics; at various schools. Presented by the American Telephone and Telegraph Company, New York, N. Y.

National Research Council—annual predoctoral fellowships; in the natural (mathematical, physical, biological) sciences; at various schools. Administered under a Rockefeller Foundation grant by the National Research Council, Washington, D. C.

Pennsylvania State College—ten graduate fellowships; for work toward doctors' and masters' degrees in aeronautical, electrical, and mechanical engineering; at Pennsylvania State College, State College.

Stevens Institute of Technology—several graduate fellowships; for hydrodynamic work; at Stevens and at neighboring graduate schools. Established by the Experimental Towing Tank Laboratory, Stevens Institute of Technology, Hoboken, N. J.

Gerard Swope Foundation—annual graduate fellowships; for advanced study in industrial management, engineering, the physical sciences, and other scientific and industrial fields; at various schools. Awarded by General Electric Company Educational Fund, Schenectady, N. Y.

Westinghouse Electric Corporation—annual postdoctoral grants; for work in pure scientific research of the appointees' own choosing; in the Westinghouse research laboratories at East Pittsburgh, Pa.

Yale Electrical Engineering Fellowship—annual graduate fellowship; for work in electrical engineering; at Yale University, New Haven, Conn. Sponsored by Westinghouse Electric Corporation.

University of Mississippi Broadens Courses. The bachelor of science degree in general engineering has been changed to a degree in engineering administration at the University of Mississippi, University. To qualify for the degree students will be required to work for six months in Mississippi industries under a co-operative arrangement. In addition, courses leading to a bachelor of science in geological engineering will be offered.

RESEARCH . . . .

Cottrell Postwar Grants for Research Are Varied

In the first year of operation of the Frederick Gardner Cottrell special postwar grants (*EE, May '46, pp 238–9*) of the Research Corporation, New York, N. Y., over $480,000 was awarded to institutions on the basis of applications by staff members for support of specific projects. Designed primarily to provide added incentive for the return to academic pursuits of the younger scientifically and technically trained personnel diverted from teaching and research by wartime activities, the program contemplates expenditure of $2,500,000 over a 5-year period in support of fundamental research projects.

In almost all cases the grants have been made initially for one year with continuance beyond that period, if desired, dependent upon report of satisfactory progress for at least six months prior to reapplication. About 20 applications for renewal have been made, with excellent supporting evidence of progress.

During the first year more than 200 applications were reviewed by the corporation's advisory committee, and favorable action was taken on more than half of them. A substantial majority of those denied were so decided because of a desire to distribute the funds to the relatively neediest institutions, and to avoid a concentration of funds in one field or at one institution, rather than relative lack of merit of the applications themselves.

Following is a partial list of the institutions, the projects, and their directors to which the special Cottrell grants have been made:

Amherst College, electrical properties of metal-solution interfaces; D. C. Grahame.

Amherst College, secondary electron emission properties of glasses and various phosphors; Theodore Seller.

California Institute of Technology, fundamental methods of computing by electric circuits; G. D. McCann.

Case School of Applied Science, X rays and electrons in the energy range 10–20-million-electron volts; R. S. Shankland, E. C. Gregg.

Cornell University, electrical properties of single crystals of semiconductors, especially the alkaline-earth oxides; R. L. Sproull.

Duke University, microwave absorption spectra of molecules; Walter Gordy.

Harvard University, resonance absorption by nuclear magnetic moments; E. M. Purcell.

Indiana University, beta disintegration process; L. M. Langer.

Linfield College, phenomena associated with field emission and re-entrance of these electrons into metals; W. P. Dyke.

Michigan State College, ionization produced in gases by electrons of energies of less than 2,000 electron volts; T. H. Osgood.

Montana State College, dielectric properties of some titanium and vanadium organo compounds; C. H. Coughlan.

New York University, nuclear disintegrations produced bv cosmic radiation; S. A. Korff.

Oregon State College, paramagnetism of monatomic gases; the magnetic susceptibilities of alkali metal vapors; A. B. Scott.

Stanford University, nuclear induction and its application to polarized neutrons; Felix Bloch.

Tufts College, lattice theory and its relation to other parts of mathematics; P. M. Whitman.

University of Alaska, analysis of gases by electron scattering and ionization; S. S. West.

University of Connecticut, fundamental research in magneto-optics (Faraday effect); C. E. Waring.

University of Kansas, theory of functions of several real variables; G. B. Price.

University of Kansas, application of radio chemical methods to problems in physical and analytical chemistry; D. N. Hume.

University of Minnesota, analysis of electron and ion collision phenomena in gases and vapors; J. T. Tate.

University of Notre Dame, electron emission mechanisms of oxide coated cathodes; E. A. Coomes, A. A. Petrauskas.

Washington University, study of energy levels of nuclei; F. N. D. Kurie.

Miniature Rolling Mill for Research. A miniature Senzimir precision cold strip rolling mill which is less than the height of a man and about as wide as an office desk, is being used in the Westinghouse Electric Corporation research laboratories, East Pittsburgh, Pa., to roll Hiperco, a magnetic alloy, for experimental use. Very thin strips of the metal are required and the mill reduces thicknesses down to 0.0005 inch.

Research Institute Organized. The Institute of Industrial Research to be operated in conjunction with the Foundation of Applied Research in San Antonio, Tex., was opened recently. The industrial research division will perform work for corporations on a fee basis and will have departments for petroleum engineering, metallurgy, chemistry, and physics. An invention development service to assist inventors who do not have the finances, facilities, and experience to market an invention is included in the organization.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Motional Mass of the Electron

To the Editor:

This is in reply to a letter to the editor by John F. Scully (*EE, March '47, pp 320–1*) discussing my paper "The Motional Mass of the Electron" (*EE, Jan '47, pp 45–60*). The problem in question has to do with the physical reactions (if any) taking place during the passage of an electron across an electric field. Contemporary theory as laid down in the text books says *nothing happens* and that the mechanical pull on the moving electron is given by the formula of electrostatics regardless of the speed of the electron through the field, as $F = E_0e$ (equation 4),

where F is the force in dynes, E_0 is the field intensity in statvolts per centimeter, and e is the charge of the electron in statcoulombs.

In this Mr. Scully agrees, arriving at his conclusion by the difficult and uncertain methods of relativity. But can the question rest here? Will this dogma, which everyone has accepted for well over a century, stay down, once the finger of doubt is raised?

For an answer to this controversy let us look just across the page from Mr. Scully's letter to the editor, to the material given by Doctor Albert Cushing Crehore, whom we all know as an authority on these matters. In the paragraph following his equation 11 he . . . has stated unequivocally that the force on an electron moving through an electric field is not given by the formula of electrostatics, equation 4. Accepting this, Mr. Scully's relativistic argument together with the whole position of classical and relativistic theory on the motional mass of the electron collapses completely . . .

In trying to find out what is wrong with my statement Mr. Scully discovers it to be "Just this: because measurements made on a system in linear unaccelerated motion with respect to another system *will fail to reveal such relative motion* (one of Einstein's postulates, and hardly speculative, since it is in perfect accord with experience)."

We wonder whether Einstein's postulates are really as bad as this since it says specifically that "measurements made on a (armature) system (of a generator) in linear unaccelerated motion with respect to another system (the field of a generator) will fail to reveal . . ." an induced voltage! Fortunately there is no difficulty in seeing the absurdity of this statement.

Mr. Scully says further that ". . . all measurements must be made with respect to the same system of reference!" and that "*We cannot introduce into our measurements a value which 'would have been found' had we considered the electron to be at rest* and the rest of the system in motion, for not only would the electric field value be different, but so would other measurements in the calculation (the length of the path traveled by the electron from the deflection plates to the screen, for example)."

These requirements are part of the relativity procedure which transfers variations in physical causes to appropriate variations in the units of measure. It is a purely mathematical device, altogether speculative and by no means "in perfect accord with experience." It adds greatly to the difficulty of seeing through a problem by transferring its physical aspects to dimensionalism, where they are obscured by the mathematics. . . .

It is a bit surprising, in this day of all out relativity to find its advocates contending that it makes a difference in the physical result, whether the charge is at rest and the field in motion, or the charge in motion and the field at rest; that is, that after all, there is something in the universe besides relative motion! The issue presents a dilemma, since an admission leads to the conclusions given in the paper while a denial is a violation of the principle of relativity.

Equation 10 is not a relativity equation as might be supposed, but a physical equation first derived by J. J. Thomson in 1881 and independently by Heaviside in 1889 by the methods of the electromagnetic theory. It has nothing to do with relativity procedures postulating changes in the units of measure of length and time. True, its derivation did assume motional interactions with a reference medium considered to be at rest, which we have had to abandon in view of the Michelson-Morley experiment. Its interpretation therefore must be altered somewhat from that originally given, a change which has not yet been applied to a number of other electromagnetic equations. . . .

We must conclude therefore that the theory of relativity, in its present form, does not provide a reliable method for the solution of electrical problems involving relative motion.

We might adopt Mr. Scully's phrase that there is no object belaboring the point further since "any conclusion drawn from a faulty premise will in itself be faulty."

It will be found that we can abandon much of the present theory of relativity and replace it with a much simpler and more satisfactory theory which treats the phenomena of relative motion from the view point of equation 10 in much the same way we now treat relative motion in generators, motors, transformers, and so forth. We can thus avoid the physically impossible conceptions of the present theory, involving contractions in length, slowing of clocks, and dimensional changes generally, which as Doctor Hovgaard forsaw would one day be "differently interpreted and physically explained."

C. A. BODDIE

(Technical consultant, office of the chief signal officer, United States Army, Washington, D. C.)

To the Editor:

The concepts of radiation are by no means fully crystallized. For this reason, the article by Mr. Boddie on "The Motional Mass of the Electron" in the January issue was studied with interest. Of far greater interest, however, were the comments on the article appearing in subsequent issues. The stimulation of thought provoked is fully attested by these comments.

Irrespective of errors in argument, or of impeachable deductions, the various facts derived from comments on papers of this nature tantalize the engineer, and lay the foundations for progress by inducing further effort at understanding.

MAXIMILIAN WARE (A '45)

(Staff engineer, office of the chief signal officer, United States Army, Washington, D. C.)

To the Editor:

Before examining the suggestions put forward by Mr. Boddie (in "The Motional Mass of the Electron"), it seems desirable to consider first the general problem of scientific knowledge. There is, indeed, a revolutionary change in the position taken by many physicists as regards the knowledge we have about the physical universe.

During the past era the general impression was that we knew fragments of absolute truth, and the ideas of absolute space, time, mass, velocity, and so forth were quite common. One had the impression that . . . many final notions had been established, the absolute truth of which never could be questioned again.

But it has been necessary to change considerably this way of thinking. In mathematics the notion of the absolute first has been disturbed by the non-Euclidean geometries: the theorems are only valid if one first accepts certain postulates, and entirely different consistent systems can be built when the postulates are different. H. Poincaré admitted that such postulates are only arbitrary conventions, accepted because they are convenient.

Later, the relativity theories have eliminated completely the notion of the absolute in connection with space, time, mass, and so on. . . .

Our mind has not, in its present state, the power to reach directly the absolute and needs to a certain extent a concrete point of view to "understand." If the abstract point of view is too far away from it, we can calculate perhaps, but we no longer understand and we may be led to what is not real, but imaginary. It is the experiment, and therefore usually the use of our senses, which enables us to make sure we are still in touch with reality and are not lost in a kind of dream. But the more we advance towards the absolute, the more abstraction is needed and experimenting becomes difficult or impossible. This difficulty of "understanding" arises of course from the fact that we try to explain the unknown by the known. We believe to know the observable things and then try to express the unobservable things by means of the observable ones, which is of course impossible when we go too far.

Physical science is therefore unable to show us the absolute and cannot give us absolute certainty, truth, or reality. All that can be done is to examine methodically the results of physical observations and by using the limited powers of our mind, to avoid errors and contradictions and to reach a harmonious structure, as simple as possible, in which all the observed "facts" can be fitted. New observations and thinking lead us to new contradictions or difficulties and make it necessary to revise the structure. . . .

We come now to Mr. Boddie's views. He says that, according to classical theory "The mechanical pull on the electron e moving at high speed through the static field E is taken to be Ee just as if the electron were at rest." Thereby this theory comes to the conclusion that the mass of the electron varies with speed. Mr. Boddie, however, believes it to be self-evident that "granting that an electron and an electric field are physical entities

possessing inertia and elasticity, we can be definitely certain that the interacting forces, when the systems are in relative motion, are different than when at rest." The author shows that with this assumption one comes to the same mathematical formulas as the classical theory.

So, we have here a case where a series of phenomena can be "explained" in two different ways: the classical one in a more abstract way, the other in a more concrete, tangible one. Which one should be preferred?

The classical theory probably will claim that it does not need any assumption regarding the "fields," while Mr. Boddie needs considerations of elasticity and inertia. It moves the difficulties towards a variable mass or field when they are in motion.

Mr. Boddie prefers to be guided by physical concepts rather than by mathematical abstractions. It is a fact that we "understand" better what is happening when we can "visualize" it.

In our opinion, the question is not, as Mr. Boddie seems to suggest: which interpretation is correct and which is false, but it should be rather: which one is more convenient?

The answer will, no doubt, depend: in certain cases, or for some minds, the one will be more convenient, in other cases, or for other people, the other will be preferable. But neither theory reaches absolute physical reality.

S. VAN MIERLO

(Laboratoire Central de Télécommunications, Paris France)

Electrical Essay Solution

To the Editor:

The "Electrical Essay for Recreation" published in the January 1947 issue of *ELECTRICAL ENGINEERING*, has aroused a gratifying interest, as shown by the letters received by the editor and myself. As a matter of fact I am happy to admit that although I had two solutions to the problem (our good editor will not publish puzzles unless you can submit an answer to them yourself) I have learned an additional solution.

Correct solutions, given in the order they were received, were submitted by Doctor Slepian, Professor T. G. Seidell, W. R. Evans, R. C. Woodhead, Professor E. W. Kimbark, Professor J. F. Lamb, J. K. Mickelsen, F. C. Strome, and Henry M. Huge. There were also four solutions missing the boat.

All the authors of the correct solutions recognized the fundamental fact that the difference between a transformer with or without load will be the presence or absence, respectively, of magnetic potential, and therefore, leakage flux between the two core legs passing through the compartment. The methods proposed to determine this leakage flux varied somewhat but most of the authors suggested the insertion of a magnetic shunt of high

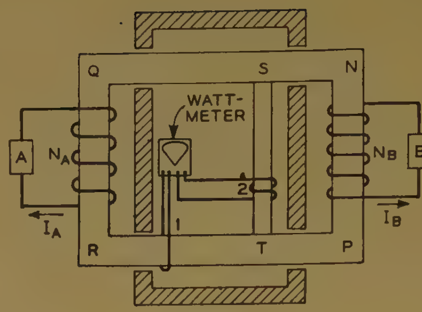


Figure 1

permeability between the two legs of the transformer; on this shunt is placed a coil, which is connected to an ammeter or to the current coil of a wattmeter. It is quite evident that this method of determining the magnetic potential appearing between the legs, or the ampere turns of the primary and secondary windings, when the transformer is called upon to furnish load current, is the same as that employed in any ordinary current transformer, where the magnetic effect, or the ampere turns of the current to be measured is determined by finding out how many secondary ampere turns are needed to wipe out the effect of the primary ampere turns. In a similar way the ampere turns of the coil placed on the magnetic shunt in the Figure 1 (which is taken from the solution submitted by J. K. Mickelsen and F. C. Strome, student test engineers with General Electric Company, Schenectady, N. Y.) will be, to quote the authors "such that the magnetomotive force produced at each instant just opposes the magnetomotive force *ST*, or *NP*, except for the small difference necessary to set up magnetization, which of course is insignificant, since the coil voltage is practically zero." (The latter is, of course, true because the coil is feeding practically into a short circuit.) Henry M. Huge points out that by making the number of turns of the two coils operating the wattmeter equal, the instrument will read actual power flow without any further need of calibration or determination of constants.

W. R. Evans, of Washington University, St. Louis, Mo., suggests a method of making use of the leakage flux worth mentioning; the same method was also suggested by Professor T. G. Seidell, of the Georgia School of Technology, Atlanta, as an alternate method to the one discussed in the preceeding paragraph. The principle is indicated in Figure 2, taken from the letter of Mr. Evans. The magnetic flux in the air gap of the shunt placed between the two legs of the transformer is proportional to the primary or secondary ampere turns (which are practically equal); the torque developed by the moving coil (which must be of low inductance so that the current flowing in it will be proportional to the voltage induced in the coil placed on the legs of the transformer) is therefore proportional to the instantaneous values of current and voltage and will therefore indicate power.

So much for the practical solutions of the problem. There can be no question about it, that they are straightforward, practical, and not open to any philosophical arguments. R. C. Woodhead, of Montreal, Quebec, Canada, states in the opening paragraph of his letter that he and his acquaintances, with whom he had discussed the problem, "were convinced, from a philosophical point of view as much as for any other reason, that it must be possible to measure the power transferred through the room." It was a matter of surprise to me that with all the experts in radar, microwave, and so forth, who can sling around Maxwell's equations with the greatest of ease, only Doctor Slepian's discussion mentioned Poynting's vector of energy flow. This vector is considered as of enough importance even by hard-headed practical engineers to have found its way into the "American Standard Definitions of Electrical Terms," sponsored and published by the AIEE. The reader is referred to section 05.40.105 on page 57 of this book (which ought to be on the desk of every electrical engineer anyway). A derivation of Poynting's vector as good as any I have seen will be found in the latest edition of the "Encyclopedia Britannica." Reduced to simple language, Poynting states that whenever there exists simultaneously an electric and a magnetic field in a region, with the direction of the two fields not coinciding, an energy flow exists at right angles to the plane determined by the directions of the electric and magnetic field, and equal to the product of the two field intensities multiplied with the sine of the angle between them and divided by 4π. To those familiar with vector analysis, this is nothing but the vector or cross product of E and H, divided by 4π. In the compartment given in the problem there exists an electric field encircling the core legs (the line integral of which we measure if we place a single turn around a leg of the transformer), and, when the transformer is loaded, a magnetic field extending from one core leg to the other (the leakage flux). If a plane surface is considered, oriented at right angles to, and pierced by the core legs and located right in the center of the compartment, the direction of the electric as well as of the magnetic field at any point of this surface would be in this plane and the two intensities would be at 90 degrees to each other right in the center of the cabinet, and at angles approaching 90 degrees for points nearer to the legs. Poynting's vector would therefore always have a direction crossing this

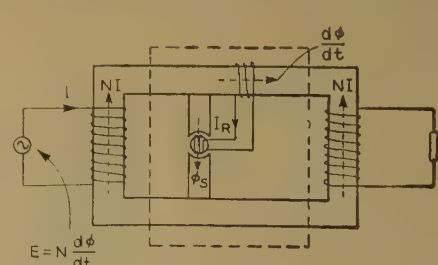


Figure 2

plane of symmetry at right angles, as common sense and philosophical meditation would also indicate.

Poynting's vector is also applicable in the first case mentioned in the electrical essay, that is, when two wires are passing through the cabinet. In this case, the electric field will extend from one wire to the other, while a magnetic field will appear encircling the wires when load current is drawn. A physicist would therefore in both cases determine the energy flow by exactly identical methods, namely by the determination of the electric and magnetic field intensity at every point of a surface stretched through the center of the cabinet, computing the value of Poynting's vector at every point of the surface, as given above, and integrating over the whole surface.

From a philosophical point of view the startling implication of Poynting's theory is that the energy does not flow in the wire or in the core legs, but in the dielectric between the conductors of electricity or magnetism. The acceptance of this theory is perhaps something that the individual will have to decide for himself, and certainly many practical engineers reject this notion as farfetched, but there is no denying the fact that an observer imbedded into the wire passing through the cabinet or into the core leg passing through the same compartment could only report the flow of electric charges, (that is current) or the presence of magnetic flux, but he could make no statement about the energy flow. The observer placed in the dielectric between the conductors on the other hand can with the aid of Poynting's vector, determine the specific energy flow taking place at every point of the compartment. Isn't it reasonable to assume that the energy flows in the region where it can be measured and observed and not in the region where such a measurement would be impossible? One might make the argument that it is just as silly to claim that the energy flows along the wire, but outside of it, as it would be to claim that the energy transfer represented by a liquid flowing under pressure in a pipe is taking place outside of the pipe. Observe this fundamental difference, however, between the hydraulic and the electrical case; an observer placed inside of the pipe could determine not only the flow of liquid, but he could also state the pressure under which it is. As already stated above, the observer imbedded into the conductor can only determine the current flow across the cross section of the conductor, but he has no means of arriving at the voltage. . .

The trick circuit of Doctor Slepian on page 318 of the March issue of *ELECTRICAL ENGINEERING* would not seem to have too much bearing on the problem as it was stated, or at least strongly implied, in the January issue, it did give rise to an enjoyable discussion between Doctor Slepian and myself (discussions with him are always enjoyable and most profitable at the same time) at the occasion of the winter meeting in January in New York. He again pointed out that there are half a dozen or so ways of defining energy flow, all of which are equally valid, if one subscribes once to the particular definition. Taking advantage of this liberty I have formed my own notion about Doctor Slepian's trick circuit and I am presenting it herewith, although I do not expect that many engineers will agree with me. I did not like a situation where the engineer within the compartment would have to go outside of it to make sure whether the measurements taken on the inside have any real meaning or not. Therefore, if I were placed in the compartment and would observe a flow of ten amperes in the wires passing through it, and a voltage of 100 volts between them, I would make the unqualified statement that an energy flow of 1,000 watts exists across it regardless of whether this is produced by a trick circuit or not. It will be noticed that in the trick circuit of Doctor Slepian there are two wires outside of the compartment; if these two wires were also carried through a compartment, an engineer stationed there would proclaim an energy flow of 1,000 watts in the opposite direction. Closer examination of the conditions shows that this energy flow, fictitious, if you will call it so, takes place in a closed loop. A hydraulic analogy might be, for instance, a doughnut shaped tube filled with liquid under pressure; if this liquid were kept in a circular motion around the doughnut by means of a propeller mounted within it, we would have a flow of liquid under pressure; the flow does not however start at one device and end at another, but closes in itself. The energy, if there is any (which is a matter of philosophical viewpoint) is seen to flow in a whirl. The physicist using Poynting's vector may also be tricked, similarly if the electric field in a given region is produced by static charges and the magnetic field by permanent magnets. Therefore, the physicist placed into a volume of space permeated by electric and magnetic fields, seemingly must at first inquire about how these fields are produced, before he can evaluate the integral of Poynting's vector and declare the existence of an energy flow. Or one can accept the viewpoint presented above, and simply declare the presence of this energy flow, because, with the arrangements of static charges and permanent magnets, the lines of energy flow will be found to form closed loops.

WALTHER RICHTER (F '42)

(Electrical engineer, engineering development division, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.)

The Sign of Reactive Power

To the Editor:

We appreciate that the common concept of kilovar flow in the power system is based on the fundamental fact that the generator supplies both the kilowatt and kilovar requirements of the common inductive load and that either of these requirements is just as real and just as positive as the other. However, the present AIEE standard has not interfered so far with the common concept of power and kilovar flow in the power system and we doubt very much that it ever will. As long as it does not interfere, it appears to us that the advantages of retaining the present standards outweigh the disadvantages. We, therefore, recommend no change.

C. D. BROWN (F '39)

(Electrical engineer, electric distribution department, Wisconsin Electric Power Company, Milwaukee, Wis.)

To the Editor:

At the suggestion of the secretariat of the British National Committee of the International Electrotechnical Commission, I have pleasure in bringing to your attention a letter which that body has addressed to the United States National Committee of the IEC, as I think the matters dealt with will be of interest to your Institute.

W. K. BRASHER

(Secretary, The Institution of Electrical Engineers, London, W. C. 2, England)

Dear Mr. McNair,

Our attention was recently drawn to a report in the November 1946 issue of *ELECTRICAL ENGINEERING*, in which it was suggested that the present convention of a negative sign for (inductive) reactive power, should be changed to a positive sign.

Comments from interested persons were invited, and we therefore brought the matter to the attention of our committee on nomenclature and symbols.

That committee does not support the proposal that the sign should be changed, their reasons being set out in memorandum *CH(ELE)8696*.

This subject has, no doubt, received some consideration by the United States National Committee of the IEC, or possibly by a committee of the American Standards Association, and we should, therefore, be glad if you would bring the views of the British committee to the attention of the appropriate committee on your side.

MEMORANDUM *CH(ELE) 8696*

Note on the Sign of Reactive Power

Under this title there is in *ELECTRICAL ENGINEERING* for November 1946, an AIEE report in which a suggestion is made that the present convention of a negative sign for (inductive) reactive power should be changed to a positive sign, and inviting comment from interested persons.

This matter has been given some attention by the technical committee on nomenclature and symbols (the appropriate committee of the British National Committee of the IEC) and as a result they wish to record that, in their view, it is preferable to retain the present convention of a negative sign rather than to change to

a positive sign. The main items which have influenced this view are as follows:

1. If the sign is derived from a comparison between a series and a parallel circuit, the parallel circuit is the more general criterion because electric power supply is based on constant voltage and not constant current, and constant voltage implies parallel circuits both in feeding a system and in taking power from it.

2. Constant voltage working usually dictates that in vector diagrams the reference quantity is voltage and from this the negative sign will result.

3. In constructing a power circle diagram by polar co-ordinates the adoption of a reference voltage must lead to a negative sign for reactive kilovolt-amperes. This practice is so widely extended that it is not likely to change and the result of a changed convention as suggested would in fact result in the use of the two signs under different types of investigation.

4. The argument (see page 515 column 2) that the customer consumes or supplies reactive power is technically unsound because, with reactive power, that supplied in one quarter cycle is returned in the next quarter cycle, and the customer neither supplies nor consumes it.

5. In practical operation the use of a positive or negative sign for reactive power is better avoided and the terms leading and lagging are happier.

J. F. STANLEY

(Assistant secretary, British National Committee of the International Electrotechnical Commission, Westminster, London, S. W. 1, England)

Engineering Approach to Security Needed

To the Editor:

If anyone in the world should be a realist, it is the engineer. But we find an amazing lack of realism in many an engineer's approach to national and international problems. The engineer who informs himself extensively regarding the background of a technical problem he is about to tackle often is the same engineer who may let wishful thinking serve as his background for the study of a social or economic problem. The engineer who spends considerable time in making a two per cent improvement in the efficiency of a rectifier tube is the same engineer who may say "what was good enough for George Westinghouse is good enough for us" when he speaks of labor-management relationships.

Everyone talks about freedom, and claims that freedom is what everyone wants—yet the men who deplored labor's call for government help are the same men who call for government protection against labor. Do we, then, honestly want freedom? The answer is that most of us want freedom for ourselves but not for our neighbors. Freedom has a status not dissimilar from that occupied by civil liberty: everyone is sure that it is his own right, but he is not sure that it is the right of the other guy.

Capitalistic democracy is engaged in a mighty struggle for prestige against another great, opposite ideology. Capitalism pretends to offer freedom. Communism pretends to offer security. Which do people want?

Let the proponents of the "American way" not be so dogmatic in their insistence that the mass of people love freedom more than security. Our industrial leaders continually assert that if every man works hard and produces a lot, we will have prosperity. If only this were so! What caused the crash in '29? Did the workers suddenly slow down or stop producing? Was there a great famine, or flood, or war, or plague which knocked the United States economy down for a count of nine? No! Whatever the complex financial causes, the worker feels he was not to blame, and all that he has done since then, however clumsy, has been in an effort to pad himself for another such calamity.

What does communism have to offer? Much that we do not want. As good engineers, however, we do not pass our competitor's product with our noses high, but rather study it with great interest to see what there is in it that might be borrowed. Security of a sort? Let's not laugh at security; most men and women spend their entire lives in trying to achieve security. The adventurers are few.

The laborer who works hard, saves, buys a house, and raises a family no longer feels secure—not after '29. He knows that his job, his savings, and his home all can go with a national economic upset, leaving him only his family. Can we blame seriously the local plumber who fights prefabricated houses, knowing that he may lose his livelihood and be forced to clerk in a grocery store or move his family to a factory town? We adventurers give him little sympathy—but perhaps he represents the norm, and *we* are the peculiar fellows.

It is well known that the man who has power is very apt to abuse it, whether that man be Caesar Petrillo, Sewell Avery, or your traffic cop. Management can not point with pride to the way the United States was run in the '20's when management was in the saddle. Nor can labor point with pride to the way it is running the United States in the '40's. Both would do better to treat the United States as being full of actual people, rather than full of hypothetical, theoretical people. Engineers are the citizens who should think most clearly; but how many do?

JOHN B. LAMBERT (A '42)

(Advance engineering section, General Electric Company, Bridgeport, Conn.)

Engineers and the Labor Act

To the Editor:

The efforts of the engineering societies to secure exemption for engineers from the compulsion to join a labor union against their wishes under certain closed-shop conditions have helped to maintain the standing of engineers and the standing of an engineering degree.

With regard to the question that it is harder to define an engineer-in-training than to define an engineer, the suggestion may be made that the afore-mentioned exemption be granted for five years to anyone who has spent his full time for a college year studying toward a bachelor degree or a higher degree at a recognized engineering college (but has not necessarily passed any examinations). Such an exemotion would be granted following any such year of study, including the final year before receiving the degree.

It seems that this rule would be workable and definite.

H. B. DWIGHT (F '26)

(Professor of electric machinery, Massachusetts Institute of Technology, Cambridge)

English Society Parallels AIEE

To the Editor:

We in young America have much to learn from our British friends, whose long history is a source of inspiration to all freedom loving people.

It is, therefore, appropriate for us to examine the history and policies of The Institution of Electrical Engineers of Great Britain, founded in 1871, and now having some 30,000 members of all sorts, of whom a little over 8,000 are students. The IEE so closely parallels AIEE that we may profitably compare their policies with ours.

Some of their worthy customs are:

1. Every new member receives a personal and confidential letter from the secretary, outlining the functions of The Institution and the responsibilities of members.

2. The Institution extends to its members a number of special services, such as the privilege of subscribing at a reduced price to "Science Abstracts," and the maintenance of a benevolent fund, including a residential estate where members may live for extended periods.

3. Admission to the higher grades of Associate Member, Member, and Fellow is jealously guarded, to preserve a high technical and professional standing in every sense for those so honored. Every such Member and Associate Member of The Institution is entitled under by-law number 8, as approved by the Privy Council, to describe himself as a Chartered Electrical Engineer. This corresponds to our American practice of licensing, with the marked difference that in Britain the engineers themselves, by government authority, control the licensing chartering procedures, whereas here the government authorities reserve the right to themselves. In practice also, it is clearly recognized that the privilege accompanying the use of the expression Chartered Electrical Engineer is an individual one, which in no way attaches to any firm or organization with which the individual is associated.

The IEE publishes a journal in three separate parts, the first of which is issued monthly, and the second and third six times a year. Part I is general, containing addresses of a general character, abstracts of all papers, progress reviews, and all proceedings and news of The Institution. Part II is devoted to "Power Engineering," and Part III to "Radio and Communication Engineering." There is also a "Students' Quarterly Journal," mainly devoted to meetings and other activities of the various student sections, the members of which receive copies free of charge, in addition to their copies of the main Institution Journal. Great importance is attached to the Research Committee of The IEE and The Institution is a sub-

stantial contributor to the funds of the British Electrical and Allied Industries Research Association, a separate body set up for the purpose of carrying out electrical researches.

The Institution recognizes seven types of member. The Corporate Members have the Honorary, Member, and Associate Member grades; and the noncorporate members include the grades of Companion, Associate, Graduate, and Student. The Companion grade corresponds to the affiliate grade sometimes used in America to indicate those who wish to receive publications and contribute to the support of the organization, but who are not concerned with the professional activities.

In view of the great shrinkage in the time dimensions of the world, and the importance of the United Nations' program, it is very desirable that more of us in America join The Institute of Electrical Engineers of Britain, and thus develop that kindred understanding and joint action on common affairs that are so much needed under present world conditions. The address of The Institution is: Savoy Place, Victoria Embankment, London, W. C. 2, England.

PHILIP L. ALGER (F '30)

(Staff assistant to manager of engineering, General Electric Company, Schenectady, New York)

Edison Semicentennial

To the Editor:

In the February 1947 issue of *ELECTRICAL ENGINEERING* the article, "Thomas A. Edison, Inventor," contains in the third paragraph of column two on page 117 a statement: "On the evening of October 21, 1931, following his interment, it also being the 50th anniversary of his effective invention of the successful incandescent lamp...". This statement is in error.

At the time of the 50th anniversary celebration of the perfection of the incandescent lamp, the "Light's Golden Jubilee" at Greenfield Village, Dearborn, Mich., on October 21, 1929, I was associated with Henry Ford at Dearborn, and in making our plans for this great occasion, we conferred with the General Electric Company lamp division, as well as Mr. Edison himself, and all agreed that October 21, 1929, was the proper date. Should we have been wrong, surely Mr. Edison would have advised us because it was necessary that he should be present to re-enact the making of a duplicate of the first lamp.

All the available data on record at the General Electric Company lamp works were consulted, and . . . I know of no better authority than these records and that of Mr. Edison himself...

J. W. BISHOP (M '42)

(Electrical engineer, power house 1, Ford Motor Company, Dearborn, Mich.)

NEW BOOKS....

Proceedings of the National Electronics Conference, Volume II. Sixty-five papers on widely varied subjects are collected in a single volume for easy and useful reference. Most of the papers presented at the National Electronics Conference, Chicago, Ill., October 3–5, 1946, are reproduced either in entirety or in abstract form. In addition, the officials and committee personnel, program of the conference, registrants at the conference, and exhibitors are listed. Subjects covered by the papers include science and politics, television, wave propagation, microwave systems, spectroscopy, instrumentation, dielectric heating, radio relay systems, radio modulation, facsimile, and nuclear physics. Copies of the volume can be obtained from R. E. Beam, Electrical Engineering Department, Northwestern University, Evanston, Ill. National Electronics Conference, Inc., 1947, 741 pages, paper bound, 6 by 9 inches, $3.50.

Radiography in Modern Industry. Intended as a text of the fundamental knowledge necessary for efficient radiographic practice, this book should meet the needs of both the professional worker and the student reader. The scope of the material presented is quite complete: the function and results of radiography; the scientific theory involved, electronics, geometry, optics, and photography; the mechanics of obtaining good radiographs; the use and processing of film; and a comprehensive bibliography. Mathematical computations are presented for several processes. The entire book is illustrated artistically and instructively. Eastman Kodak Company, X-Ray Division, Rochester, N. Y., 1947, 122 pages, $8^1/_2$ by 11 inches, $3.00.

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

MATRIX AND TENSOR CALCULUS WITH APPLICATIONS TO MECHANICS, ELASTICITY AND AERONAUTICS. (Galcit Aeronautical Series). By A. D. Michal. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1947. 132 pages, diagrams, tables, $9^1/_4$ by 6 inches, cloth, $3.00. Matrix calculus and tensor calculus are dealt with separately in the two parts of this book. The minimum of mathematical concepts is presented in the introduction to each part, with the more advanced mathematical ideas being developed as needed in connection with the material on applications. Although the emphasis is on aeronautical and mechanical applications, such as vibrations, aircraft flutter, elasticity, hydrodynamics, and fluid mechanics, the purpose is to provide a working knowledge of use in many technical fields.

INTRODUCTION TO MATHEMATICAL STATISTICS. By P. G. Hoel, John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1947. 258 pages, diagrams, charts, tables, $8^1/_2$ by $5^1/_2$ inches, cloth, $3.50. Sampling inspection, design of experiments, testing of statistical hypotheses, analysis of variance, sequential analysis, and nonparametric methods of analysis are important topics dealt with in this comprehensive introduction to modern statistical methods. The first seven chapters of the book are concerned largely with the theory of certain classical large-sample methods arranged according to the number of variables. In the last five chapters some important small-sample methods are considered along with other modern developments.

THEORY OF FUNCTIONS OF REAL VARIABLES. By L. M. Graves. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1946. 300 pages, diagrams, 9 by $5^3/_4$ inches, cloth, $4.00. This book offers a compact presentation of the theorems and methods which are fundamental for research in analysis. The more basic and generally useful parts of the theory of functions of real variables are treated in detail, together with many results not usually found in standard treatises on the subject, such as some of the theorems on implicit functions, differential equations, and Lebesgue and Stieltjes integrals. The more advanced material is indicated by stars for omission on first reading.

APPLIED MATHEMATICS FOR ENGINEERS AND PHYSICISTS. By L. A. Pipes. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1946. 618 pages, diagrams, charts, tables, 9 by $5^3/_4$ inches, cloth, $5.50. This text covers those topics of higher mathematics (series, differential equations, matrices, special functions, vector analysis, and so forth) which form the essential mathematical equipment of a scientific engineer or a physicist. The material dealt with is general in nature and includes the fields of electrical, mechanical, and civil engineering as well as the mathematics of classical physics. The mathematics of mechanical and electric oscillations, electric field theory, modern operational calculus, nonlinear oscillations, and potential field theory is clearly set forth. References accompany each chapter.

ANALYTIC GEOMETRY AND CALCULUS. By J. F. Randolph and M. Kac. The Macmillan Company, New York, N. Y., 1946. 642 pages, diagrams, tables, $9^1/_2$ by 6 inches, cloth, $4.75. In this book analytic geometry and calculus are treated together in such a way that each complements the other. The object is to provide an early presentation of the concepts of calculus as an aid in other technical subjects. By using two sizes of type and different groups of problems, the sections suitable for the average college class are distinguished from those intended for more extended study, thus widening the usefulness of the book. Answers are provided for selected problems.

ADVANCED MATHEMATICS FOR ENGINEERS. Second edition. By H. W. Reddick and F. H. Miller. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1947. 508 pages, diagrams, tables, $8^1/_2$ by $5^1/_2$ inches, cloth, $5.00. Assuming a knowledge of mathematics through the calculus, this book begins with the theory and standard methods of manipulation of ordinary differential equations. Succeeding chapters deal with various special functions, integrals, series and equations, with vector analysis, probability, and the operational calculus. To emphasize physical applications, problems are presented, with each principal topic, relating to the main fields of engineering. In this revised edition, an appendix has been added giving a brief discussion of dimensional analysis and systems of physical units.

SERVOMECHANISM FUNDAMENTALS. By H. Lauer, R. Lesnick, and L. E. Matson. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1947. 277 pages, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $5.00. The purpose of this book is to introduce the engineering student and the practicing engineer to the principles underlying the theory of servomechanisms. It offers a complete derivation of the basic properties of servocontrol devices and systems, and their direct relation to the simple physical principles that govern their operation. Working formulas, curves, and diagrams are also given, together with many practical examples and problems. Particular emphasis is placed on the transient analysis of simple servomechanisms.

NUCLEAR PHYSICS TABLES. By J. Mattauch with an Introduction to Nuclear Physics by S. Fluegge, translated from the German by E. P. Gross and S. Bargmann. Interscience Publishers, New York, N. Y., 1946. 173 pages, illustrated, diagrams, charts, tables, 11 by 7³/₄ inches, cloth, $12.00. Stable and unstable nuclei, nuclear reactions, and the systematics of stable nuclei are discussed in the concise introduction to nuclear physics which stresses experimental results and methods. Part II is a complete listing of numerical values of the properties of stable and unstable nuclei, especially of half-period values, terms, and energies, and of all known nuclei reactions. The reactions are presented in a 4-color graphic scheme for ease in follow up, and over 1,000 literature references give the original sources of the tabular material.

MESON THEORY OF NUCLEAR FORCES. By W. Pauli. Interscience Publishers, New York N. Y., 1946. 69 pages, charts, tables, 8¹/₄ by 5¹/₄ inches, cloth, $2.00. This small book contains a series of lectures intended to provide a first orientation in the recent theory of the interaction of mesons with protons and neutrons (nucleons) and the interactions between nucleons derived from it. The main experimental data to be explained are stated first, followed by the mathematical development of the theory.

COSMIC RADIATION. Fifteen lectures edited by W. Heisenberg, translated by T. H. Johnson. Dover Publications, New York, N. Y., 1946. 192 pages, illustrated, diagrams, charts, tables, 9¹/₂ by 6 inches, cloth, $3.50. The fifteen lectures collected in this book were presented in Germany in 1941 and 1942. They are grouped broadly as follows: an introductory review of the present state of knowledge of cosmic radiation; two papers on the cascade theory; nine papers dealing with mesons; two papers on nuclear particles; and one paper on geomagnetic effects. Although the work of several authors, the material is well integrated, with cross references, and a consistent notation. A general view is given of recent accomplishments and outstanding problems in this branch of physics. There is a general index.

COLLEGE TECHNICAL PHYSICS. By R. L. Weber, M. W. White, K. V. Manning. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1947. 761 pages, illustrated, diagrams, charts, tables, 9¹/₄ by 6 inches, cloth, $4.50. This book presents the basic ideas of physics for students of science and engineering. Topics regarded as essential for a first-year course are carefully developed in logical order, to give the student an exact knowledge of fundamental principles and to enable him to apply these principles with confidence and facility in the solution of technical problems by the scientific method. Brief chapters on electronics, polarized light, and other special topics are included. A necessary minimum of mathematics has been used for the benefit of the beginning student.

APPLICATIONS OF GERMICIDAL, ERYTHEMAL, AND INFRARED ENERGY. By M. Luckiesh. D. Van Nostrand Company, New York, N. Y., 1946. 463 pages, illustrated, diagrams, charts, tables, 8¹/₂ by 5¹/₂ inches, cloth, $5.50. In the early chapters the relative effects of radiant energy in the ultraviolet, visible, and infrared regions are discussed, chiefly with regard to their relation to human welfare. Succeeding chapters describe methods for the killing of air-borne and water-borne bacteria and for the prevention of contamination of food and other products. The production and characteristics of artificial sunlight are discussed, and also the increasing applications of fluorescence and of infrared energy. Special topics, such as the fading of materials, ultraviolet and plant life, radiant energy in common illuminants, and the measurement of ultraviolet energy are also considered.

MECHANICS OF MATERIALS. Second edition By P. G. Laurson and W. J. Cox. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London England, 1947. 422 pages, illustrated, diagrams charts, tables, 8¹/₂ by 5¹/₂ inches, cloth, $4.00. With the needs of the student in mind, this text presents a full treatment of the fundamentals needed for a minimum course. Additional chapters on the more advanced aspects of beam and column analysis, stresses and deflections, loaded connections, and so forth are included to provide fuller coverage for those who wish it. The physical behavior of stressed bodies has been emphasized throughout as well as the mathematical expression of this behavior. More than 600-graded problems are provided.

RELAXATION METHODS IN THEORETICAL PHYSICS. By R. V. Southwell. Clarendon Press, Oxford, England; Oxford University Press, New York, N. Y., 1946. 248 pages, illustrated, diagrams. charts, tables, 9¹/₂ by 6 inches, cloth, $7.00 (20s abroad). The author's earlier treatise, "Relaxation Methods in Engineering Science," dealt with the application of these methods to systems of finite freedom (frameworks, electric networks, and so forth) and continuous systems (elastic beams) which are governed by differential equations in one space variable. This second treatise applied the method to problems governed by partial differential equations involving two space-variables, and by conditions which must be satisfied on boundaries of specified shape. The 24 examples which it treats in detail have been taken from elasticity, hydrodynamics, electricity and magnetism, the conduction of heat and so forth; and they include systems characterized by symmetry with respect to an axis, to which (in general) the method of conformal transformation is not applicable.

DRAFTING FOR ELECTRONICS. By L. F. B Carini. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1946. 211 pages, illustrated, diagrams, charts, tables, 9¹/₄ by 6 inches, cloth, $2.50. This text and reference manual sets forth the principles of schematic drafting as applied to electronics, starting with a review of drafting fundamentals, and covering thoroughly the planning, development and reproduction of specialized drawings for this field. All material is based upon approved standards of the American Standards Association and the Institute of Radio Engineers. A special chapter covers graphical methods for the presentation of data. A 9-page list of illustrative motion pictures and filmstrips is included.

TELECASTING AND COLOR. By K. S. Tyler. Harcourt, Brace and Company, New York, N. Y., 1946. 213 pages, illustrated, diagrams, 8¹/₂ by 5¹/₂ inches, cloth, $2.75. Each step of a program from its inception in the studio to its appearance on the television receivers is explained in simple language. Information is given on black-and-white television, color television, and a new system of transmission called pulse time modulation, a method of transmitting sound and picture together. The necessary equipment is described in detail, and there is a discussion of the duties of the operating personnel in studios and control room. A short bibliography is appended.

INTRODUCTION TO ELECTRON OPTICS. By V. E. Cosslett. Clarendon Press, Oxford, England; Oxford University Press, New York, N. Y., 1946. 272 pages, illustrated, diagrams, charts, tables, 9¹/₂ by 6 inches, cloth, $6.50. This book provides a connected treatment of the production, propagation, and focusing of electron and ion beams. Its main subject is the theory of electron lenses, including aberrations, and their applications in cathode-ray tubes and electron microscopes. Attention also is paid to other devices employing electron beams in radio and atomic physics. The mathematical treatment has been subordinated to the description of physical principles. Reference lists are appended to each chapter, and a table of electronic data is included.

FUNDAMENTALS OF INDUSTRIAL ELECTRONIC CIRCUITS. By W. Richter. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1947. 569 pages, illustrated, diagrams, charts, tables, 9¹/₄ by 6 inches, cloth, $4.50. Striking a middle course between the popular treatment and the exhaustive treatise, this book aims to show the fundamental principles applying to circuits containing vacuum tubes. These circuits are reduced to a combination of more familiar circuit elements so that the average electrical engineer and practical man can analyze the performance of the circuits and can design them himself. Illustrative sketches, circuit diagrams, and practical problems effectively supplement the text material.

ELECTRICAL NETWORK CALCULATIONS, TABULAR METHODS OF SOLUTIONS. By D. E. Richardson. D. Van Nostrand Company, New York, N. Y., 1946. 270 pages, diagrams, charts, tables, 9¹/₄ by 6 inches, cloth, $5.75. The purpose of this book is to provide students and practising engineers with an efficient arithmetic tool for use in securing numerical solutions to electric network problems. For example, instead of using the usual algebraic equations in solving for the currents of a d-c network, the electromotive force and resistance values are tabulated according to a prescribed form and performing a series of similar, repeated arithmetic operations with these tabulated quantities. Tabular procedures likewise are used for a-c network solutions. Detailed, worked-out examples are included for illustration.

ELEMENTARY THEORY OF GAS TURBINES AND JET PROPULSION. By J. G. Keenan. Oxford University Press, New York, N. Y.; Geoffrey Cumberlege, London, England, 1946. 261 pages, illustrated, diagrams, charts, tables, 9 by 5¹/₂ inches, cloth, *12s/6d* ($5.00 in United States). This treatise presents the basic principles of the gas turbine in as simple a manner as possible while retaining the mathematical essentials. The concept of entropy is omitted, and the changes in the condition of the gas flow are dealt with on a pressure-volume basis. The history of the gas turbine is traced briefly, followed by chapters on the air cycle, compressors, combustion chambers, nozzles, heat exchangers, impulse and reaction turbines, gas turbine efficiencies, and calculations. Descriptions of installations for locomotives, ships, generating stations, and gas turbine-airscrew aircraft are given, with a special chapter on aircraft jet propulsion.

ALLEN'S DICTIONARY OF ABBREVIATIONS AND SYMBOLS. By E. F. Allen. Coward-McCann, Inc., New York, N. Y., 1946. 189 pages, 7³/₄ by 5 inches, cloth, $3.50. The major part of the book consists of some 6,000 abbreviations alphabetically arranged. The abbreviations are ones commonly used in a wide variety of fields such as: literature, science, engineering, business, politics, religion, and so forth, and where more than one word or phrase is represented all are given. At the back of the book several pages are devoted to classified groups of symbols used in typography, mathematics, astronomy, and a few other fields.

VAN NOSTRAND'S SCIENTIFIC ENCYCLOPEDIA. Second edition. D. Van Nostrand Company, New York, N. Y., 1947. 1,600 pages, illustrated, diagrams, charts, tables, maps, 10¹/₂ by 7 inches, cloth, $10.00. Considerably revised, this comprehensive reference work presents in detail over 10,000 separate subjects dealing with the principles and applications of the physical sciences, medicine, and technology, from aeronautics to zoology. The presentation of each topic, beginning with a simple, nontechnical definition and progressing to the more advanced phases, is helpful to the general reader. In addition to the customary cross references, all terms in the main alphabetical list are printed in heavy type wherever they appear in the context. Diagrams, sketches, and data tables are included wherever they will be of particular use.

PAMPHLETS . . .

Mica. Superintendent of Documents, Government Printing Office, Washington 25, D. C., 1947, 89 pages, 25 cents.

Traffic Engineering and the Police. By H. K. Evans and F. M. Kreml. National Conservation Bureau, New York, N. Y., and Traffic Division, International Association of Chiefs of Police, Evanston, Ill., 1946, 104 pages, $2.00.

Receiving Tube Manual. Electronics Department, Tube Division, Building 267, General Electric Company, Schenectady, N. Y., 1947, 700 pages, $5.00.

Clarified Schematics Rider Manual Volume XV and "How It Works" supplement. John F. Rider, Publisher, Inc., 404 Fourth Avenue, New York 16, N. Y., 1946; manual, 2,000 pages, $18.00; supplement, 200 pages.

HIGHLIGHTS........

New. Here is the first issue of *Electrical Engineering* to be issued under the new publication policy described in the December issue (*EE, Dec '46, pp 576–8*). It is a first step; many elements of the program necessarily remain to be brought into operation as rapidly as conditions permit. Heavier paper is being used for improved appearance and readability. Also, three general-interest sections which were withdrawn in 1942 because of wartime restrictions are being reinstated with this January issue and will be developed further in later issues. These are the "Industrial Notes," "New Products," and "Trade Literature" departments which appear on page 36 of the advertising section.

Winter Meeting. The AIEE winter meeting will take place this year in New York, N. Y., January 27–31, 1947. Although the program as scheduled thus far is not yet in final form, its tentative contents indicate that many enjoyable and informative sessions have been planned for those who attend (*pages 75–9*).

Expansion. Continued growth of AIEE membership and consequent increased requirements for headquarters space finally have exceeded the capacity of space available in the Engineering Societies Building and expansion into commercial office building space has become necessary. Therefore the editorial and advertising staff, being largely self-contained, has been established as the publications department at 500 Fifth Avenue, New York 18, N. Y.

Questionnaire. A survey of vacuum tube types by the AIEE subcommittee on electronic instruments was announced recently (*EE, Nov '46, p 531*). Questionnaires now are available for companies interested in participating. Information obtained will be reported in a future issue.

Atomic Bomb Tests. Since the Bikini tests there has been widespread publicity concerning the effect of atomic energy on the future security of the world. Too much of the material released before the tests was of a sensational nature and the public was disappointed at the actual although scientifically predicted results. Quite naturally a complacent attitude has developed because of the letdown from the sensationalism. Official United States scientific observers at Operation Crossroads did not limit their views to the physical aspects of the bomb blasts, but have stressed the importance of control of atomic usage (*pages 1–5*). An extremely large amount of information was collected and extensive measurements were made by means of electronics at Bikini. Television, remote control, telemetering, radio and radar monitoring, and timing equipments all had important functions to carry out. In addition to developing and using electronic tools the electronics staff of Joint Army-Navy Task Force One prepared more than 3,800 electronic equipments for the tests and then determined and compiled data on damage results (*pages 6–10*).

Electronic Recording Instruments. Digests of several of the discussions which took place at a conference on electronic recording instruments during the 1946 AIEE summer convention in Detroit, Mich., include a brief history of automatic recording, comments on the use of these instruments in industrial measurement, and some facts about sweep-balance recorders. D-c to a-c conversion systems, the input transformer problem, and a new high-speed recording potentiometer also are discussed (*pages 36–44*).

Electric Power in China. Because China has been essentially an agrarian nation, electric power development has been extremely slow, reaching but 1.7 watts per capita of installed generating capacity by 1944. However, under two postwar power development programs planned by the Chinese National Resources Commission, China hopes to achieve a capacity of approximately 4.8 watts per capita within the next five years (*pages 67–74*).

Electronics in Measurements. Although electronic methods can make some measurements cheaper and faster than is possible by conventional devices, they have a number of limitations which make them impractical for widespread use. Their advantages are such, however, that the development of electronic measuring instruments suitable for heavy-duty industrial service is highly desirable (*pages 31–5*).

Relativity and Electromagnetic Laws. A straightforward, authoritative, elementary exposition of the present generally accepted theory on the forces between moving charges is presented in this issue (*pages 61–5*). In effect this is a direct and emphatic rebuttal of the revolutionary theories put forth in the article "An Analysis of Electromagnetic Forces" previously published (*EE, Oct '45, pp 351–6*), and also discussed in intervening "Letters to the Editor." The author supports Einstein's theory of relativity in clarifying the fundamental electromagnetic laws. Also in this issue appears "The Motional Mass of an Electron" (*pages 45–60*) in which the author presents a very lucid discussion of the same generally accepted theories, but denies the validity of certain equations.

Quality Control. The basis of quality control is the study of variations in process, a study which has assumed new significance since the evolution of highly complicated assemblies. It is important, therefore, that the principles of statistical quality control be understood by all concerned in the manufacturing process, a not-too-formidable undertaking when it is realized that this highly developed theory is founded on the elementary laws of chance (*pages 16–19*).

Mexican Industrialization. The fact that two thirds of Mexico's population is agriculturally employed would seem to indicate that Mexico is primarily an agricultural nation. On the contrary, however, it means that Mexico's most serious problem is the over-population of its farming lands. This condition, plus the Mexican government's efforts to raise the standard of living of the country as a whole, provide a good case for Mexican industrialization on a large scale (*pages 26–31*).

Rural Electrical Problems. The general subject of rural electrification is depicted as presenting two phases which separately challenge the ingenuity of the electrical engineer: electrification (the bringing of electric service into rural areas), and electroagriculture (the usage of electric power for farming). The latter, especially, is a new industry which is badly in need of engineering thinking (*pages 20–5*).

Analysis of Measurements. In recognition of the need for a practical system for analyzing all types of measurement apparatus, a method is proposed which takes cognizance of the fact that all such systems are composed of but three functional parts: a primary detector, one or more intermediate means, and an end device. The objective is to analyze and organize data that have been used in the field, but in an unsatisfactory and indefinite manner (*pages 11–15*).

Electrical Essay. Because previously published electrical essays have elicited much interest on the part of our readers, another is presented in this issue. Can you solve the problem (*page 44*)?

News 75

ELECTRICAL ENGINEERING. Published monthly by the American Institute of Electrical Engineers; publication office 20th & Northampton Streets, Easton, Pa. Editorial and advertising offices, 500 Fifth Avenue, New York 18, N. Y. Subscription $12 per year plus extra postage charge to all countries to which the second-class postage rate does not apply; single copy $1.50. Entered as second-class matter at the Post Office, Easton, Pa., under the Act of Congress of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538, P. L. & R. Act of February 28, 1925. January 1947, Vol. 66, No. 1. Number of copies of this issue 36,300

Drop-wire undergoing abrasion tests in birch thicket "laboratory." Below, the new drop-wire, now being installed.

WE'RE GLAD THAT BIRCH TREES SWAY

The telephone wire which runs from the pole in the street to your house is your vital link with the Bell System. More than 17,000,000 such wires are in use.

The wire becomes coated with ice; it is ripped by gales, baked by sun, tugged at by small boys' kite strings. Yet Bell Laboratories research on every material that goes into a drop-wire—metals, rubbers, cottons, chemicals—keeps it strong, cheap, and ready to face all weathers.

Now a new drop-wire has been developed by the Laboratories which lasts even longer and will give even better service.

It has met many tests, over 6 or 7 years, in the laboratory and in field experiments. It has been strung through birch thickets —rubbed, winters and summers, against trees, and blown to and fro by winds. In such tests its tough cover lasts twice as long as that of previous wires.

House by house, country-wide, the new wire is going into use. Wire is only one of millions of parts in the Bell System. All are constantly under study by Bell Telephone Laboratories, the largest industrial laboratory in the world, to improve your telephone service.

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EXPLORING, INVENTING, DEVISING AND PERFECTING FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE

HIGHLIGHTS........

Omission. Because of a last-minute change, the "Industrial Notes," "New Products," and "Trade Literature" departments which were to have been resumed with the January issue did not appear. These departments are included in this issue on pages 14A, 16A, and 26A of the advertising section.

Winter Meeting. Early reports of the Institute's 1947 winter meeting will appear in the March issue of *Electrical Engineering*. Advance registrations as this issue goes to press indicate that the meeting, technical program of which will be the largest in the history of the Institute, will be well-attended and that the all-time high of 2,624 registrations recorded last year may be exceeded.

Edison Centennial. This year, 1947, marks the 100th anniversary of the birth of Thomas Alva Edison, an event which is being widely observed by AIEE Sections. In this issue, *Electrical Engineering* presents a biography of Edison written in 1932 by a past-president of the Institute and an associate of Edison (*pages 113–17*), a discussion of Edison's associations with the AIEE (*page 118*), and a history of the Edison Medal (*pages 122–3*). The first AIEE technical paper, on the "Edison effect," is reproduced from volume 1 of the AIEE *Transactions*, published in 1884 (*pages 119–21*).

Chinese Industrialization. In a discussion of China's future, the Chinese Ambassador to the United States stresses the fact that with the solution of her present internal problems, his country will be well on the road to an epic period of industrial expansion. By raising the standard of living of China's millions, a program of industrialization not only will provide a lucrative market for foreign goods, but also should provide a great opportunity for the investment of foreign capital (*pages 131–4*).

Southeast Power Pool. In recent years in only one area of the United States has power curtailment been deemed necessary. This was in the Tennessee-Alabama-Georgia section in 1941. The causes of this emergency and the methods employed to meet it are described by the man who was in charge of power co-ordination for the Power Branch of the Office of Production Management (*pages 166–70*).

Labor Versus Management. The basic issue in labor–management relations at the moment arises from the fact that each group is concerned primarily with its own *individual* survival, and its attention is focused on the means to that particular end. The problems and idea fixations involved on both sides of the labor–management feud have been the subject of extended field research by a noted economist whose observations are summarized in this issue (*pages 124–30*), and who voices the warning that the result of continuing failure to work out the means of mutual survival will not be the elimination of one group by the other, but the elimination of both groups as free institutions by legislative regimentation.

Canadian Engineering Organization. In view of current interest in the subject of engineering organization, and the many points of similarity between professional problems in the United States and Canada, a discussion of Canadian engineering organization since the formulation of the first Canadian engineering society in 1887 is presented (*pages 146–8*).

History of Electronics. The tremendous strides made by the electronics industry, especially in the field of communications, during the last 25 years are summarized on pages 171–7 by a man who is associated with a large electrical manufacturer.

Temperature and Depreciation. Already utilized as a guide to equipment operation, temperature also can serve in the determination of depreciation, inasmuch as it is the prime factor influencing the rate of deterioration of common nonceramic insulation materials. This method consists, in brief, of an application of engineering analysis to the temperature performance history (*pages 182–6*).

News Index

A-C Heating. Although both induction and dielectric heating are based upon molecular structure disturbances, the methods differ in that induction heating is the generation of heat in conductive materials while dielectric heating is essentially a voltage phenomenon with the ability to create heat within nonmetallic and poor-conducting material. Each method thus has its own distinctive field of application, although occasionally some substance might present a choice of methods (*pages 149–60*).

Communication Measurements. A tabulation of the most frequently used communication data taken from telephonic, acoustic, and electronic fields has been prepared for convenient reference. This table answers the need of the engineer who is required to review data from the field of communication engineering only to find that these data are expressed in units that are difficult to relate to those associated with his normal work (*pages 135–40*).

Missouri Basin. The proposed hydroelectric development of the Missouri Basin embodies two aspects: the engineering aspect which is concerned primarily with the development of power, and the economic aspect which is concerned primarily with its utilization. With this dual approach, a government spokesman asserts that the generation of low cost power in abundance will create its own market and so will provide a major stimulus to the expansion of regional economy, thus benefiting the community as a whole (*pages 140–5*).

Aids for the Blind. Those individuals who have been handicapped by loss of sight are faced by problems probably more serious than those of any other disabled group. Many new instruments have been devised for these persons to aid them in deriving a livelihood, and numerous devices for guidance and for reading of printed material are in the process of development (*pages 178–82*).

Railway Motive Power. The type of power to be used by locomotives always has been a problem to railway engineers. Comparisons of the leading three contestants, reciprocating steam, Diesel-electric, and electric power, are given on pages 161–6. These comparisons are based on operating experiences in the Pacific Northwest.

Organization of the Engineering Profession. Because their content touches so directly upon matters not only of current concern but of lasting significance to the Institute, an exchange of letters between a member of the Institute and AIEE Secretary H. H. Henline discussing the proposed reorganization of the engineering profession is included with the letters to the editor (*pages 211–12*).

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HIGHLIGHTS........

Record Meeting. A verified registration of 3,567 establishes the 1947 AIEE winter meeting in New York at an all-time high point, some 36 per cent above the previous record of 2,624 established last year. A comprehensive news report reflecting the highlights of 29 technical sessions, 10 technical conferences, 3 administrative conferences, and some 51 committee and subcommittee meetings is given in this issue of *ELECTRICAL ENGINEERING* (*pages 265–301*).

Bell Centennial. The 100th anniversary of the birth of Alexander Graham Bell, who became an AIEE Member in 1884, is observed in this issue with a biography, especially prepared for *ELECTRICAL ENGINEERING*, which should serve not only to commemorate the life of a great inventor, but also to remind the reader that the early genius did not develop his great contribution overnight (*pages 215–29*). The Edison Medal address delivered in 1915 by Thomas A. Watson (F '15) when Bell became Edison Medalist is reproduced on pages 232–6.

Collective Bargaining. Culminating long study of the relationships in which engineers find themselves under current interpretations of the Wagner Act, the board of directors of the American Institute of Electrical Engineers during the recent winter meeting in New York adopted the resolution authorizing President Housley "in his discretion, to proceed in efforts to bring about a revision of the National Labor Relations Act which will secure for engineers freedom of choice in the matter of collective bargaining" (*page 297*).

National Security. "There is the greatest probability that the first battlefields of the next war will be the industrial cities of the United States." In preparation for such an eventuality, Lieutenant General Ira C. Eaker, deputy commander in the United States Army Air Forces, cautions Americans against building a defensive structure based on the last war. He warns that the success of any plan for national security will depend upon the speed of mobilization of man power and industry, the modernity of our weapons, and the degree of national interest on the part of the American citizen (*pages 237–40*).

Awards. Three medals were awarded during this year's winter meeting to AIEE members who have distinguished themselves in science, industry, or public life. The Edison Medal was bestowed upon Lee de Forest (F '18) on Tuesday, January 28, for his achievements in radio and for his invention of the grid-controlled vacuum tube. On Wednesday, January 29, Lewis Warrington Chubb (F '21) received the John Fritz Medal which is awarded jointly by the four national engineering societies for notable scientific or industrial achievements, and on Thursday, January 30, the Hoover Medal, also a joint award, was presented to Vannevar Bush (F '24) for distinguished public service. Full text of the main addresses at the medal presentation ceremonies are included in this issue (*pages 254–64*).

Physics and Engineering. Today's principles of physics will become tomorrow's engineering practice. This familiar relationship between physics and engineering is illustrated in the story of the development of the magnetron, a story from which two important conclusions may be drawn: first, new principles must be discovered and started on their way toward translation into practical applications, and, second, since final success is based on co-operation rather than individual effort, individual results must be reported promptly so that they may be developed further by others in the field (*pages 241–3*).

Steering of Ships. Prior to World War II full electrical steering of ships was not employed very extensively in the United States, but, as a result of the war emergency, many of the newer ships are equipped with steering facilities for full electric drive and control. Because European practice has utilized electrical steering for many years, the Ward Leonard power supply system actuated by AEG electrical control, which is in general use abroad, is described in this issue (*pages 244–8*).

Postwar Television. The majority of postwar television receivers fall into two categories, direct view and projection, thus outmoding to a great extent the indirect view receiver which was common in prewar years. This is one of the design characteristics which should help to make the new receiver a superior product from the standpoint of performance, utility, reliability, and minimum obsolescence (*pages 249–53*).

Motional Mass of Electron. The contemplated conference discussion of the article "Motional Mass of the Electron," published in the January 1947 issue of *ELECTRICAL ENGINEERING*, did not materialize at the basic sciences session during the recent winter meeting, because of program congestion. Considerable informal discussion ensued, however, and discussion of the subject probably will continue through the columns of *ELECTRICAL ENGINEERING* pending availability of program space for a conference discussion at a later meeting (*pages 319–21*).

Official Nominees. B. D. Hull of the Southwestern Bell Telephone Company of St. Louis, Mo., has been nominated for the AIEE presidency for 1947–48 (*page 301*). Also announced are the nominees for vice-presidents, directors, and treasurer. Biographical sketches of the candidates will appear in the April issue of *ELECTRICAL ENGINEERING*.

TVA Deficit. The Edison Electric Institute charges the Tennessee Valley Authority with an over-all deficit of $8,041,000 for the fiscal year ending June 30, 1946. The EEI's assertion is based on the latest annual TVA report (*page 309*).

Electrical Exposition. Among the more interesting "additional attractions" for those who attended the AIEE winter meeting in New York was the Electrical Engineering Exposition which was held concurrently at the 71st Regiment Armory (*page 309*).

Correction. In the article "Induction and Dielectric Heating" by Kennard Pinder which was published in the February 1947 issue of *ELECTRICAL ENGINEERING*, pages 149–60, the title of Table II should read "Depth of Penetration of Induced Currents in *Micrometers*" instead of "...in *Millimeters*" as printed.

News Index

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March 1947, Vol. 66, No. 3. Number of copies of this issue 36,800

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HIGHLIGHTS........

AIEE PROCEEDINGS. Distribution of the AIEE *PROCEEDINGS* listed in the first order form (*EE, Feb '47, pp 33A and 34A*) now is well under way. The second order form for the *PROCEEDINGS* sections appears on pages 55A and 56A of this issue. Both North Eastern District and summer general meeting papers are included on the one form. Abstracts describing these papers appear on pages 401–2 of the April issue (for North Eastern District papers), and on pages 607–14 of this issue (for summer meeting papers).

AIEE Meetings. Preparations have been completed for the AIEE summer general meeting to be held in Montreal, June 9–13. The complete technical program appears in this issue (*pages 591–4*). Arrangements also are being made, and a number of events tentatively have been scheduled, for the Pacific general meeting, to be held this year in San Diego, Calif., August 26–30 (*page 596*).

Sunspot Storms. Current studies of sunspots lead the experts to believe that within the next few years, the earth is due for severe magnetic disturbances which will be manifestations of storms having their source near the center of our solar system. Technical advances have prepared telegraphic systems to weather such storms which formerly caused sizeable disruptions (*pages 557–60*).

Board of Directors. At a recent meeting of the AIEE board of directors, the president was authorized to appoint a special committee on legislation "to assist him in the attempt to effect a satisfactory revision of the National Labor Relations Act" (*pages 597–8*).

Single-Side-Band Carrier. Because he believes it may be "a better solution than extending the frequency band" for the problem of crowded frequencies, the author submits this new system of generation for use of power lines for communication (*pages 549–52*).

Transformer-Loss Compensator. Satisfactory performance is reported of a new transformer-loss compensator (*pages 538–42*).

Television Progress. Many people are optimistic regarding the future of television broadcasting, while others recall that television has been "just around the corner" for many years. As an index of the present status of the industry, less than 10,000 television receivers were produced during 1946. However, an upward trend is indicated by the fact that more than 5,000 receivers were built during January 1947 (*pages 580–90*).

The Electrical Engineer. The career of Thomas Alva Edison serves as an example of the extent of the electrical engineer's attainments. As a means of gaining national recognition for these attainments, the author supports the establishment of an over-all engineering organization (*pages 521–4*).

High Frequency Heating. The electronic heating industry has assumed major proportions during the past few years and so a number of interested groups, including an AIEE subcommittee formed for that purpose, actively are seeking means with which to combat one of its main problems: the interference with radio communications of radiation produced by electronic equipment (*pages 570–6*).

Motional Mass. If the field of a particle is calculated from Maxwell's equation and the energy associated with the field is evaluated, it is found that the part of the energy which does not depend on the velocity gives Einstein's equation and the part which depends on the velocity gives Newton's equation when the velocity is small compared with that of light (*pages 561–4; see also pages 624–6*).

News Index

Power Sources. Electrostatic forces resulting from the presence of the electric charge, said to be the most direct and powerful forces in nature, are involved in the multielement vacuum tube—the basis of all electronic communication and control—as well as in some methods for the generation and storage of electric energy (*pages 525–34*).

Interconnected Systems. The necessary organization, planning, and procedures for the successful operation of an interconnected system are discussed on pages 553–5. In addition to these three contributing factors, successful operation is dependent on a desire for success by the management of each of the interconnected systems.

Transformer Protection. "Whenever a fault in a transformer is beginning to form, heat is produced locally, which begins to decompose solid or liquid insulating material and, consequently, to produce inflammable gas." This fact has led to the development of gas-actuated relays for transformer fault protection (*pages 564–9*).

Hydraulic Turbine Efficiency. The efficient operation of hydroelectric equipment has been discussed many times. However the subject is of prime importance to many power engineers and a repetition of the methods of improving efficiency is worth while (*pages 542–6*).

Social Studies for Engineers. After the engineering student is acquainted with the rudiments of social studies, the greatest possible freedom should be allowed him in pursuing particular phases that arouse his interest. A proposal has been made to implement this policy by combining required basic freshman courses with a maximum use of electives for advanced courses (*pages 535–7*).

Adjustable-Frequency Power Systems. High-speed variable-frequency induction motors are used widely for wind tunnel tests on powered airplane models. The power conversion equipment used to supply adjustable-frequency power is described on pages *576–9*.

Acceleration Measurement. Acceleration can be measured with a vacuum tube consisting of a fixed cathode and two elastically mounted plates. The output at 10 g is sufficient to drive a high-frequency recording galvanometer directly. The tube has a natural frequency of about 800 cycles per second, a flat response up to 200 cycles per second, and a linear range to 150 g (*pages 555–6*).

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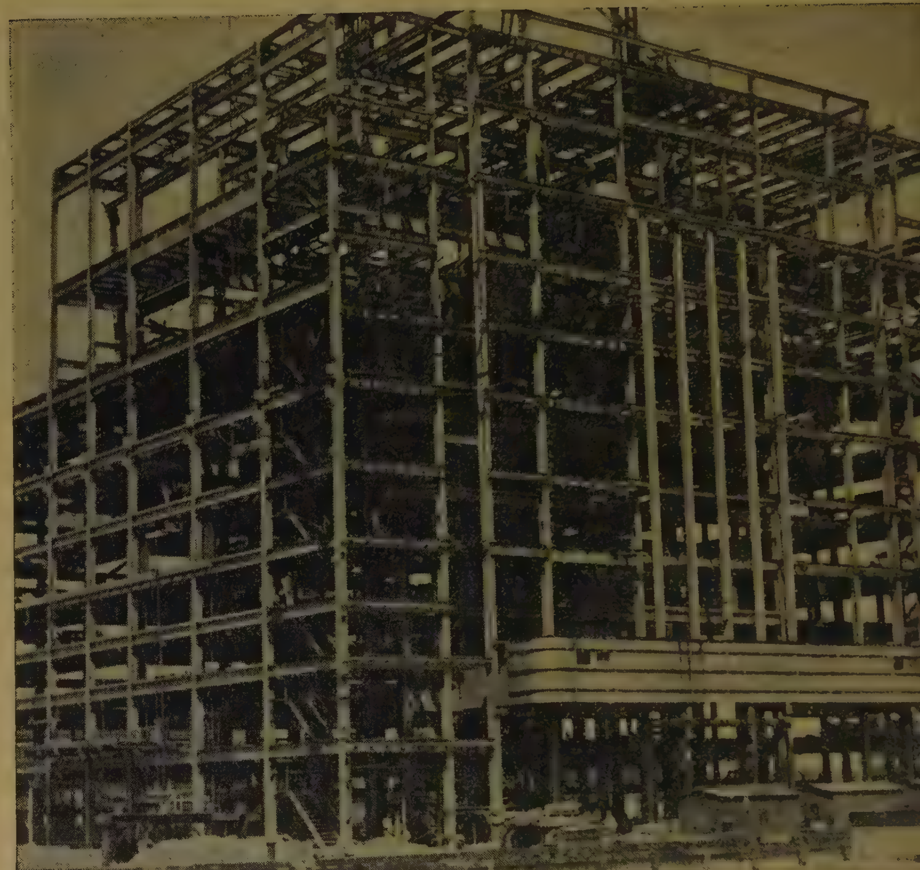

POWER HOUSE—Southwark Power Station of Philadelphia Electric Company. American Bridge Company fabricated and erected the Power House, Maintenance Shop, Boiler House, Electric and Heater Bay, Turbine Room, Switch House, Administration Building, Turbine Supports and Coal Handling Structures.

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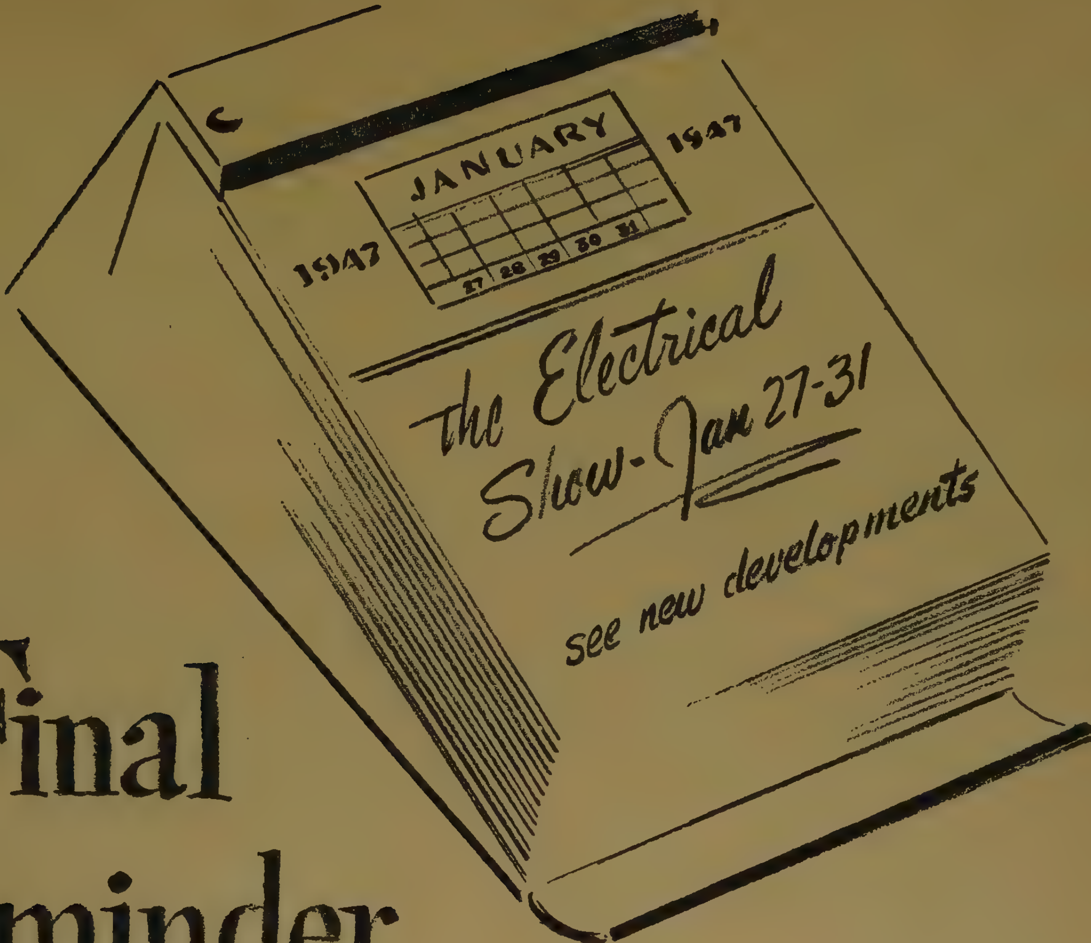

Final Reminder

The Electrical Engineering Exposition . . . the show electrical men of all interests have wanted for years . . . becomes a reality *this month*—January 27–31! So mark these dates on your desk pad NOW . . . make attendance at this show a "must" . . . bring key associates, too. Plenty of opportunities to supplement your fund of working knowledge will be awaiting you here.

SEE the many informative displays of latest equipment, materials and practices for the generation, transmission, distribution and application of electrical energy. Think how much time you'll save . . . the many advantages you'll gain . . . by studying and comparing all that's new at one time under one roof!

TALK over problems and plans with engineering specialists on hand. Learn about new ways to get things done better, faster, more profitably.

GET time—and money-saving ideas on design, installation, operation, maintenance, production, sales . . . more ideas than you could get in any other comparable time or way.

TAKE advantage of this opportunity to make yourself more valuable to your company . . . no matter what your interest in electricity, this Exposition offers plenty you can't afford to miss. Be sure to attend.

ELECTRICAL ENGINEERING EXPOSITION

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To be held concurrently with Winter Convention of American Institute of Electrical Engineers

Under management of International Exposition Co., Grand Central Palace, N. Y. C.

NEW PRODUCTS • • •

(*Continued from page* 16A)

volts d-c and 60-ampere radio-frequency currents. Because of its rigid construction there are no audio frequency-mechanical resonances in the capacitor to interfere with its operation in high-voltage plate-modulated tank circuits.

Home Precipitron. First models of a household Precipitron have moved off the assembly line of the B. F. Sturtevant Company Division of the Westinghouse Electric Corporation at Hyde Park, Mass., and will soon be available through contractors in the major cities with the greatest dirtfall problem. These cities are: Detroit, Pittsburgh, Philadelphia, Cleveland, Cincinnati, Chicago, Milwaukee, St. Louis, New York, Buffalo, and Columbus. The unit is about the size of a refrigerator and installation requires a water supply and drainage outlet, a 115-volt a-c supply, and duct work to fit the unit into the heating or ventilating system. Water supply and drain are required or periodic cleaning of the dust-collecting plates.

Portable Hardness Tester. The Ames Precision Machine Works, Waltham, Mass., have introduced a hand-held hardness tester for rounds and flats up to one inch. Screw action is employed to force penetrators into the material tested and the readings are obtained in both Rockwell B and C scales.

Small Synchronous Motor. The R. W. Cramer Company, Centerbrook, Conn., is producing a precision-built self-starting synchronous motor of high operating efficiency. The *SX* Motor is only $2^3/_8$ by $2^1/_8$ by $1^1/_2$ inches in size. It has an extremely high torque of 30 inch-ounces at 1 rpm. Input power is only 2.7 watts at 115 or 230 volts, 60 cycles. To provide speeds from 60 rpm to 1 revolution in 24 hours, 28 gear trains make the *SX* adaptable to a wide variety of applications such as timing devices, recording instruments, communications equipment, traffic controls, heating controls, and signaling systems.

TRADE LITERATURE • • •

Microwave Plumbing. Catalog, 18 pp. Describes the mechanical and electrical features of the ultrahigh frequency equipment as well as some of its applications and uses. Standard Components and Test Equipment. DeMornay Budd, Inc., 475 Grand Concourse, N. Y.

Welding. Folder, 4 pp. Gives essential information on the development, advantages, and applications of a new line of "Low-Temp" EutecTrodes for arc welding. Each type can be applied at lower base metal temperature, thus reducing greatly the ill effects of the higher heats usually necessary in arc welding. Arc Welding at Lower Base Metal Temperatures. Eutectic Welding Alloys Corporation, 40 Worth Street, New York 51, N. Y.

Miniature Tubes. Folder, 4 pp. Gives a table of miniature electron tube characteristics and ratings. Hytron Reference Guide for Miniature Electron Tubes. Hytron Radio and Electronics Corporation, Salem, Mass.

Lamps. Bulletin *LD-1*, 76 pp. Contains technical data from a wide range of bulletins and articles published by the engineering division of the lamp department. Condensed text on the design and operation of incandescent, mercury, and fluorescent light sources; lamp economics; temperatures; voltages; auxiliary equipments; and germicidal, infrared, sunlamps, and glow lamps. Illustrated. General Electric Lamp Bulletin. General Electric Lamp Department, Nela Park, Cleveland, Ohio.

Flash Welding Equipment. Bulletin *130-A*, 30 pp. Describes principles of flash welding, design and construction of the company's machines, and lists capacities and characteristics. Sciaky Brothers Inc., 4915 West 67th Street, Chicago 38, Ill.

Ceramic Compositions Properties. Chart. Describes the properties of the more frequently used AlSiMag compositions used for electrical and electronic insulators, holders for electronic heating devices, spray nozzles, and as cores and inserts for precision castings. American Lava Corporation, Chattanooga 5, Tenn.

High-Frequency Heating and Melting. Bulletin *27*, 8 pp. Describes principles and advantages of induction heating and melting, and shows many ways to use high-frequency equipment for many jobs. Ajax Electrothermic Corporation, Ajax Park, Trenton 5, N. J.

Radio and Television Receiving Tubes. Booklet Form *1275-C*, 16 pp., $0.10. Charts, characteristics, and socket connections of RCA receiving tubes for television, frequency modulation, and standard broadcast. Information on discontinued types included. The booklets may be obtained from RCA tube distributors. Commercial Engineering, Tube Department, Radio Corporation of America, Harrison, N. J.

Radio Manufacturers. Directory, 99 pp. Membership list and trade directory, with data on personnel, products, and organization and production code symbols of the Radio Manufacturers Association. Lists 335 electronic manufacturing companies. An abridged edition excluding RMA organization is also being printed. Specify whether abridged or complete edition in writing. Radio Manufacturers Association, 1317 F Street, Northwest, Washington 4, D. C.

Electronic Tube Data. Catalog *86-020*, 16 pp. Lists tubes according to class—phototubes, thyratrons, ignitrons, phanotrons, and so forth. Separate index arranged by type number. Also included is interchangeability chart showing equivalents for competitive type numbers. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh, Pa.

Insulation Materials. Booklet, 24 pp. Contains complete information on Fiberglas yarns, wire, tapes, cordage, braided sleeving, cloth, and other insulating materials. Tables and charts giving technical data are included. Owens-Corning Fiberglas Corporation, Nicholas Building, Toledo 1, Ohio.

Water Conditioning. Booklet *28X6385*, 12 pp. Touches upon the importance of feedwater control, care of testing equipment, obtaining samples, test procedures, and carries handy reference tables to assist in reporting results. Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

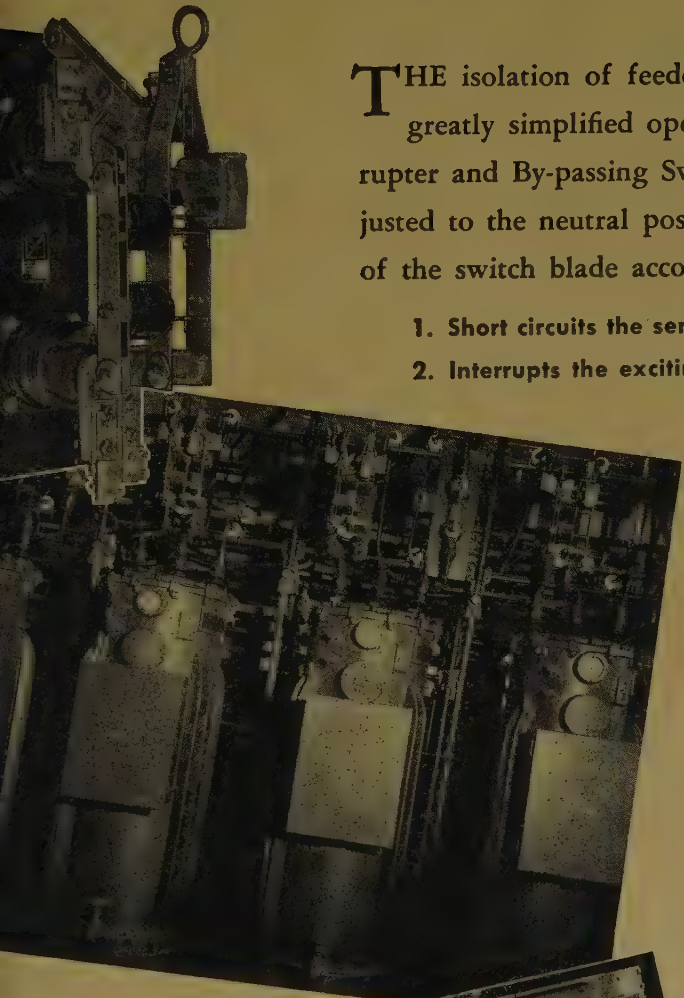
Power and Gas Tubes. Booklet Form *PG-101*, 16 pp., $0.10. Covers characteristics of RCA air- and water-cooled power tubes, voltage regulators, thyratrons, ignitrons, and gas rectifiers. The booklets may be obtained from RCA tube distributors. Commercial Engineering, Tube Department, Radio Corporation of America, Harrison, N. J.

Recording Materials. Booklet, 44 pp. Describes photographic recording materials for use with cathode ray oscillographs, galvanometer oscillographs, and similar instruments. Includes information on physical and photographic properties of films and papers. Industrial Photographic Sales Division, Eastman Kodak Company, 343 State Street, Rochester 4, N. Y.

Synchronous Motor Control. Booklet Volume 7 Number *3*, 20 pp. Relates the development of synchronous motor control and describes in detail how polarized field-frequency control works. Electric Machinery Manufacturing Company, 821 Second Avenue Southeast, Minneapolis 13, Minn.

Brush Spring Calculator. A handy Brush Spring Calculator covering springs for all fractional horsepower motor brushes and prepared in "slide rule" form is being offered free by the Stackpole Carbon Company, St. Marys, Pa., to brush designers and motor engineers who request it on company stationery.

OW Convenient, Dependable Switching
IN FEEDER REGULATOR INSTALLATIONS



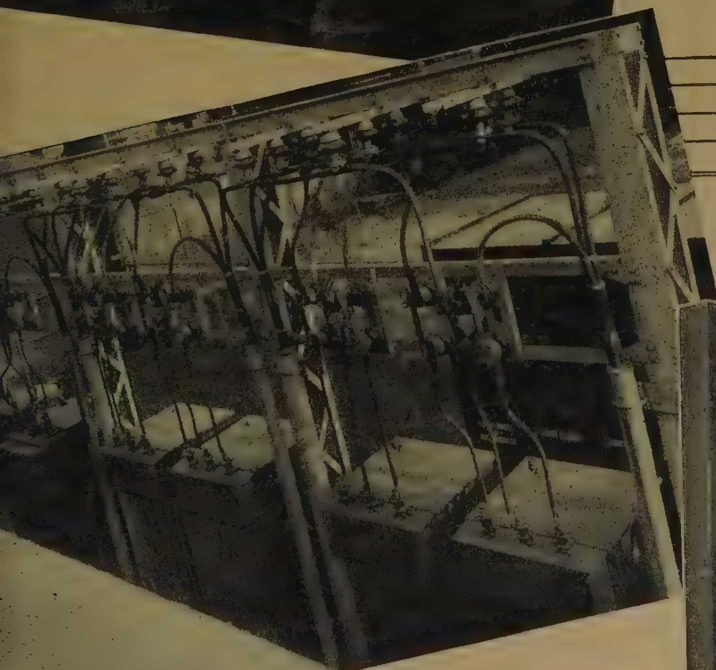
THE isolation of feeder regulators for inspection and repair becomes a greatly simplified operation with the installation of S & C Load Interrupter and By-passing Switch Combinations. With the feeder regulator adjusted to the neutral position and the control circuit interrupted, operation of the switch blade accomplishes the following:

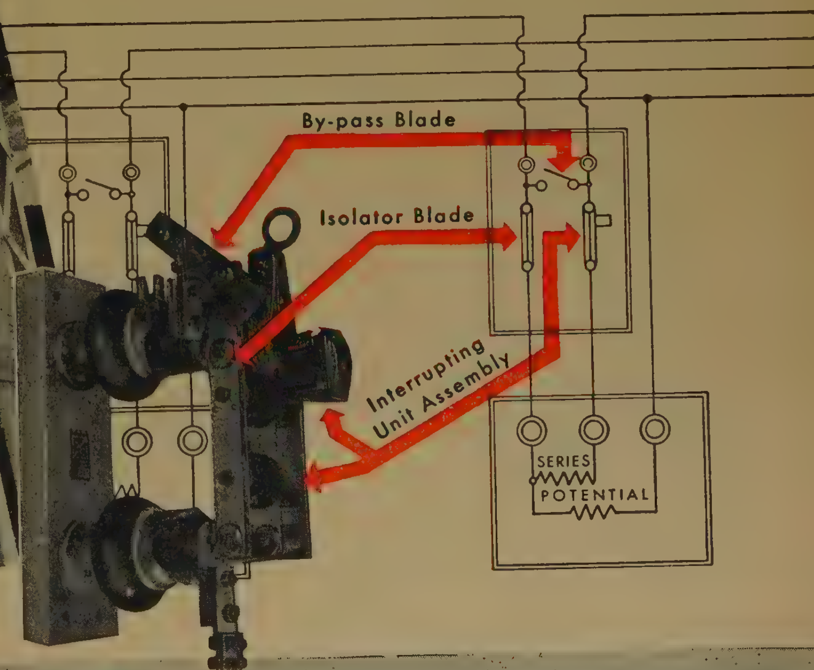
1. **Short circuits the series winding.**
2. **Interrupts the exciting current, and isolates the regulator from the line.**

In this way the regulator is isolated in one common operation, and with the assurance that there will be no arcing at the switch contacts to introduce any uncertainty.

These modern by-passing and isolating switch combinations are designed to provide a definite air break when open, and are equipped with porcelain insulation throughout. They may be installed outdoors or indoors without enclosures . . . thereby holding installation costs to a minimum.

This is just one of the many possible applications where S & C Load Interrupter Switches offer real convenience, often with distinct cost savings, and it will pay you to have full information. Write today.

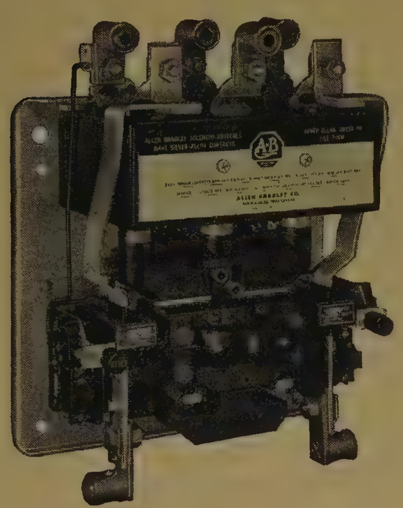




SCHWEITZER & CONRAD, INC.
4427 Ravenswood Avenue Chicago 40, Illinois, U.S.A..

NEW PRODUCTS . . . .

Solenoid Starter. Allen-Bradley Company, Milwaukee, Wis., has developed the Bulletin 709, size 5, solenoid motor starter, which has a maximum rating of 100 horsepower at 220 volts and 200 horsepower at 440–550–600 volts, to replace the Bulletin 710, size 5, clapper starter. Over-all size of the unit



has been decreased, but the wiring space has been increased thereby facilitating ease of installation. The starter is mounted on a self-insulated metal base plate, and can be provided with or without an enclosure.

Mercury Switch. Motor loads up to two horsepower can be handled by the Mercu-Trol relay made by Mack Electric Devices Company, Elkins Park, Pa. The unit has one moving part, a positive free floating magnetic plunger operating in a hermetically sealed tube. Mercury to mercury contact is established in an inert gas in the heavy glass enclosure.

Test Set. A vacuum tube-bridge characteristic test set, designed to reduce operator fatigue and eliminate personal errors frequently resulting from circuit arrangement has been announced by Sylvania Electric Products, Inc., New York, N. Y. The console unit includes bridge and auxiliary switchgear mounted on a control shelf, electronically regulated power channels, bridge signal source, amplifiers, meters, and other accessories.

Midget Ultraviolet Lamp. A midget ultraviolet Sterilamp drawing $3^1/_2$ watts and designed for application in home refrigerators has been announced by Westinghouse Electric Corporation, Bloomfield, N. J. The lamp, which emits bacteria-killing rays, is reported to retard spoilage and cut down food odors.

Electronic Vibration Tester. Vibration in such equipment as motors, blowers, fans, grinders, and so forth, can be checked with the Model *11-B* Vibrometer made by Televiso Products Company, Chicago, Ill. Vibrations are transmitted from the vibrating surface to a piezoelectric Rochelle salt crystal through an aluminum extension rod. Three types of vibration—displacement, velocity, and acceleration—are registered on a calibrated meter scale of a vacuum tube voltmeter with frequency response from 5 to 2,500 cycles per second.

Lucite Light Globes. Street light globes made of Lucite acrylic resin, a transparent plastic, have been developed for use where vandalism occurs. According to E. I. du Pont de Nemours and Company, Wilmington, Del., the plastic has excellent light diffusion properties and the additional quality of impact resistance.

Dual Electric Brakes. Two independent braking systems for use on heavy vehicles include an electric retarder based on the principle of the eddy current brake, and a separate system of conventional shoe brakes controlled by an electromagnetic circuit. The system has been developed by the Warner Electric Brake Company, Beloit, Wis.

Large Weatherproof Motors. A complete line of outdoor weatherproof motors in sizes ranging to and above 2,000 horsepower is being made now by Allis-Chalmers Manufacturing Company, Milwaukee, Wis. Incorporated in the new line is a redesigned ventilation, heat transfer system which is claimed to make air passages practically self-cleaning.

Electric Thermometer Bulb. A new Thermohm resistance thermometer bulb has been announced by the Leeds and Northrup Company, Philadelphia, Pa., which has a temperature range up to 1,000 degrees Fahrenheit. Speed of response is much faster than that of heavy-gauge couples, although the 6- or 12-inch long unit is of rugged construction. The temperature coil is thoroughly protected against contamination by moisture and gases.

Fish Line. Either a compressor or bottled gas can be used to "shoot" through a conduit a fish line developed by T. J. Cope, Inc., Philadelphia, Pa. Flexible rubber cups of the pneumatic device will pass over minor obstructions, and where water, loose sand or leaves are encountered the cups will carry everything before them, performing a cleaning operation. A crank and gear reduction for re-reeling the wire disengages when the 1,000-foot stranded wire is being rodded through a conduit.

Overload Safety Clutch. An automatic safety clutch device made by the Polaroid Corporation, Cambridge, Mass., attains complete disengagement of two connected rotary machine parts by automatic introduction of a lubricant between the frictional surfaces at the instant that one of the rotary parts is overloaded.

Signal Generator. Type-*hp-610A* UHF signal generator, announced by Hewlett-Packard Company, Palo Alto, Calif., is a compact source of ultrahigh frequency current in the range from 500 to 1,350 megacycles for laboratory use as a standard for determining gain or alignment; obtaining antenna data or measuring standing-wave ratios; for reading signal-to-noise ratio, circuit *Q*, or transmission line characteristics. Radio-frequency output may be continuous, amplitude modulated, pulsed, or square-wave modulated.

Materials Tester. The presence of voids, cracks, porosity, laminations, poor bonds, and other internal flaws in metals, plastics, and ceramics can be determined by a new ultrasonic tester introduced by the General Electric Company, Schenectady, N. Y. The instrument consists of a high-frequency generator, a crystal transducer for producing ultrasonic vibrations, a medium such as water to transmit the vibrations, a second crystal transducer to convert received mechanical energy into electric signals, and an indicator. Changes of viscosity, compressibility, and density of liquids can be determined if they alter the velocity or attenuation of ultrasonic transmission.

Lighting Guide. A new Footcandle Selector which indicates lighting recommendations for more than 75 seeing tasks has been announced by the General Electric Company Lamp Department, Nela Park, Cleveland, Ohio. The $2^1/_2$- by $2^3/_4$-inch selectors are available for 10 cents through the lamp department's district sales offices.

Tape Recorder. Continuous half-hour recordings are possible with the newly available Soundmirror recorder-reproducer being produced by the Brush Development Company, Cleveland, Ohio. Recordings can be erased, or they can be edited by cutting and splicing with cellulose tape which does not affect playback quality.

Hermetic Seals. By a new process perfected by Hermetic Seals Products Company, Newark, N. J., a variety of shapes in multiple headers with as many terminals as desired molded into a cover unit can be turned out. The Hermico-Glass headers are vacuum tight, have a resistance of over 10,000 megohms between body and terminals or between terminals, have a permanent chemical bond between metal and glass, possess a matched coefficient of expansion, and can withstand the shock of hot tin dipping to facilitate soldering.

PIONEERS IN CABLE ENGINEERING

THE KERITE COMPANY

NEW YORK · CHICAGO · SAN FRANCISCO · LOS ANGELES

INDUSTRIAL NOTES....

Service Facilities. A new combined service shop and warehouse in Baltimore and similar facilities in Denver have been added to the network of apparatus repair and replacement centers maintained by the General Electric Company. This brings to 25 and 28, respectively, the number of General Electric service shops and warehouses located in principle cities throughout the country. The Denver shop is located at 3353 Larimer Street and is equipped to service the surrounding area including Colorado, Montana, Wyoming, western South Dakota, western Nebraska, and northern New Mexico. The Baltimore shop is at 920 East Fort Avenue and will serve Maryland, Delaware, and parts of Virginia and Pennsylvania.

Trackless Trolley Orders. Orders for new trackless trolley coaches during 1946 totaled more than the entire production of the industry for 12 years before the war, according to four leading trolley coach manufacturers. Contracts calling for 3,264 new vehicles totaling nearly $60,000,000 are on the books of Pullman-Standard Car Manufacturing Company, ACF-Brill Company, St. Louis Car Company, and Marmon-Herrington, Inc.

Affiliated Companies Department Formed. The General Electric Company has established an affiliated manufacturing companies department, and has appointed L. R. Boulware, vice-president formerly on the company president's staff, as general manager. Among the affiliates are: Carboloy Company, Inc., General Electric X-Ray Corporation, Hotpoint, Inc., Locke Insulator Corporation, Monowatt Electric Corporation, Telechron, Inc., and Trumbull Electric Manufacturing Company.

New Vice-President for Colonial Radio. L. S. Kimball, general manager of the flourescent fixtures division of Sylvania Electric Products, Inc., has been elected vice-president in charge of operations of the Colonial Radio Corporation, Buffalo, N. Y., a wholly-owned subsidiary of Sylvania.

Rockbestos Adds Operating Space. The Rockbestos Products Corporation, New Haven, Conn., has recently completed the addition of more than 11,000 square feet to its operating facilities in preparation for the increased demand expected for its products—permanently insulated wires, cables, and cords.

Westinghouse Reports Loss. Gwilym A. Price, president of the Westinghouse Electric Corporation, estimated in a year-end statement that the company would show an operating loss of more than $50,000,000 for 1946. Because of the carry-back features of the wartime tax law, the company has been protected against this loss, which otherwise would have been a crippling blow to its financial strength according to Mr. Price. Included in the year-end statement was the announcement of a $573,069,453 backlog of orders and substantial progress in the $132,000,000 postwar expansion and reconversion program.

Army Award to Westinghouse Vice-President. The War Department has announced the award of the Army Certificate of Appreciation to Walter Evan, vice-president in charge of all radio activities for the Westinghouse Electric Corporation, for "his contribution to the Signal Corps in connection with the development and production of radio and radar equipment during World War II."

Manufacturing Director for Meck Industries. A. H. Carey, former factory manager for the Sprague Electric Company, North Adams, Mass., was recently appointed as director of manufacturing for the John Meck Industries, Plymouth, Ind.

RCA Builds Two Hundredth Electron Microscope. The first Radio Corporation of America electron microscope was built in 1940 and took one year to complete. The two hundredth instrument was completed in December 1946 and was turned over to Doctor P. E. Klopsteg, director of research at the Technological Institute of Northwestern University, Evanston, Ill.

Honeywell Expands. A further move in the Minneapolis-Honeywell Regulator Company's $4,000,000 expansion program has been disclosed with the announcement of the lease of a new building in Minneapolis, Minn.

Lamperti to Graybar Board. A. C. Lamperti, secretary and controller of Graybar Electric Company, New York, N. Y., has been elected a member of the board.

Concentrated Installation Data. National Electric Products Corporation, Pittsburgh, Pa., has concentrated service fitting installation data for underfloor duct wiring distribution systems into a simple "Box Tox" sheet. National Electric believes that such distribution of installation suggestions will greatly expedite service fitting installations, as well as simplifying catalog pages.

Union Pacific Orders Locomotives. The Union Pacific Railroad announced in December 1946 that it had ordered 64 Diesel-electric passenger, freight, and switching locomotives from the American Locomotive Company, the Electro Motive Division of General Motors Corporation, and the Fairbanks-Morse Company. Total cost of all the engines will be $22,000,000.

Increase in Lamp Life Rating. The Lamp Department, General Electric Company, Nela Park, Cleveland, Ohio, has announced that the life rating of the 3,000-watt *A-H9* mercury lamp has been increased from 2,000 to 3,000 hours with no change in electrical characteristics or initial ratings. Life ratings have also been increased for the 400-watt *A-H1*, *B-H1*, and *F-H1* mercury lamps from 3,000 to 4,000 hours when burned 5 hours per start, and from 5,000 to 6,000 hours when burned 10 hours per start. The company announced that these 1,000-hour life rating increases apply to lamps currently in stock.

Synthetic Rubber Compounds. According to an announcement by the Simplex Wire and Cable Company, Cambridge, Mass., synthetic rubber compounds will be the standard insulation for their products in the future. Technical data and reasoning which brought about the declaration are contained in the new booklet "Our Third Report to Industry on Simplex Synthetic Rubber Insulations."

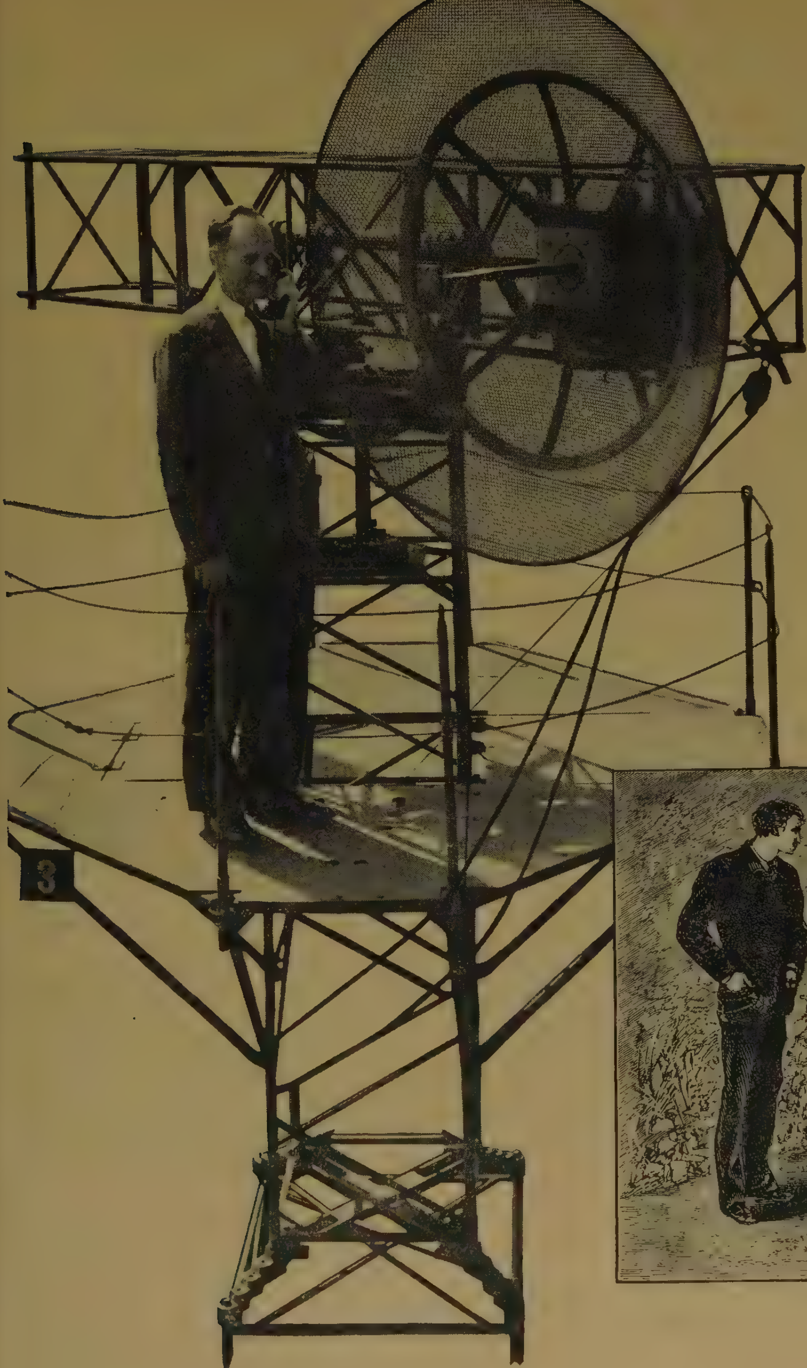
New Factory. All departments of the Sentinel Radio Corporation are now consolidated in the company's new plant in Evanston, Ill.

NEW PRODUCTS....

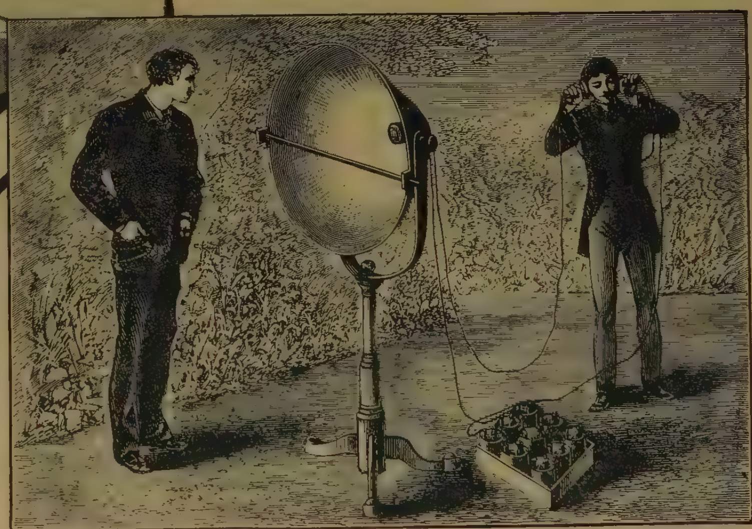
Thickness Gauge. The Audigage manufactured by the Branon Instruments, Inc., Joe's Hill Road, Danbury, Conn., is a portable instrument to measure the thickness

of many materials, including steel, from one side only. It utilizes a crystal-type gauge head, powered by a frequency-modulated electronic oscillator. When the vibrating crystal is applied to a wall surface, the fund-

(*Continued on page* 16A)



Words that rode on a beam of light



If Alexander Graham Bell could look at the microwave antenna in the illustration, how quickly his mind would go back to his own experiments, 67 years ago!

For in 1880 the inventor of the telephone had another new idea. Speech could be carried by electric wires, as Bell had demonstrated to the world. Could it be carried also by a *light beam?*

He got together apparatus—a telephone transmitter, a parabolic reflector, a selenium cell connected to handphones—and "threw" a voice across several hundred yards by waves of visible light, electromagnetic waves of high frequency.

Bell's early experiment with the parabolic antenna and the use of light beams as carriers was for many years only a scientific novelty. His *idea* was far ahead of its time.

Sixty years later communication by means of a beam of radiation was achieved in a new form—beamed microwave radio. It was developed by Bell Telephone Laboratories for military communication and found important use in the European theater. In the Bell System it is giving service between places on the mainland and nearby islands and soon such beams will be put to work in the radio relay.

In retrospect, Bell's experiment illustrates once again the inquiring spirit of the Bell System.

BELL TELEPHONE LABORATORIES

EXPLORING AND INVENTING, DEVISING AND PERFECTING FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE

(*Continued from page* 14A)

mental and the harmonic frequencies at which the wall section will resonate are directly proportional to the velocity of the sound in the material and inversely proportional to the thickness. The Audigage provides a means whereby audible signals are produced corresponding to harmonic resonance. The frequency difference between any two adjacent audible signals as read on the tuning dial is readily converted into wall thickness on a concentric thickness scale. The character of the audible indications provides additional information such as kind of material, condition of reflecting surface, back-up liquids, and process scale.

Aircraft Radio Aids. The Radio Corporation of America introduced four new lightweight compact radio aids to aircraft navigation and communication at the first annual National Aircraft Show at Cleveland, Ohio: an automatic direction finder, a general purpose aircraft communications receiver, a navigational and communications very-high-frequency receiver, and a personal plane transmitter. The first three, any of which may be used for the dual purpose of communications and radio direction finding, are specially designed and constructed to fit into half of the standard aircraft rack space and weigh much less than conventional equipments of this type. The new transmitter is designed for mounting in the standard 3-inch instrument panel opening.

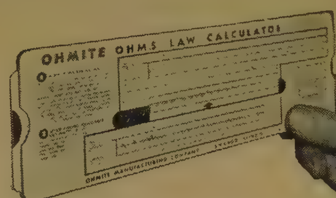
Enclosed Street Lighting Luminaire. Designed specifically for mercury vapor lamps a new type *OV-20* enclosed street lighting luminaire announced by the Westinghouse Electric Company, East Pittsburgh, Pa., directs approximately 50 per cent of the lamp output on the roadway as compared with the 27 to 30 per cent of useful output produced by previous units. The new luminaire produces a more uniform pavement brightness for higher visibility on the street. Control of the light at the higher angles plus the use of special glassware makes the refractor appear uniformly luminous over its entire width when viewed from any angle. The result is a source of high candlepower having a comparatively low surface brightness and less glare.

Resistor. The Ward Leonard Electric Company, Mount Vernon, N. Y., announced the development of a plug-in type resistor designed for use with single-lamp portable fixtures for operation of fluorescent lamps on direct current. Operating as an adapter unit, this fixed resistor unit requires no wiring and is connected in series with the auxiliary d-c ballast.

Subminiature Thyratron Tube. Designed specifically for amateur and intermittent service, the *RK61* is now being manufactured by the special tube section of Raytheon Manufacturing Company, Newton, Mass. Similar in characteristics to the Raytheon *RK62*, the *RK61* is much smaller and lends itself to ultra-compact design. It is designed for use as a self-quenching superregenerative detector which will operate a high resistance relay in the anode circuit upon reception of a radio signal. The flexible terminal leads may be soldered directly to circuit components without the use of a socket.

Drafting Pencil. An aluminum drafting pencil, known as the Elastichuck Pencil, has been introduced by the Elastichuck Sales Company, Inglewood, Calif. A rubber collet is the only contact between the lead and pencil. The hardened steel chuck cannot be damaged when sharpening leads against a file or sandpaper pad. A roll-stop keeps the pencil from rolling off an inclined drawing board. Pencils are available either in single-end or double-end models.

Ohm's Law Calculator. A new pocket-size Ohm's Calculator has been announced by the Ohmite Manufacturing Company, 4937 Fluornoy St., Chicago, Ill. The



device will give the answer to any Ohm's law problem, and will also solve parallel resistance and series capacitance problems. Its range is suited for problems commonly encountered in both radio and industrial work. The varnished cardboard calculator is nine by three inches, and is priced at 25 cents.

Coated Glass. Protection of instruments from stray currents and elimination of fogging on windshields has been obtained by a recently disclosed development of the Pittsburgh Plate Glass Company, Pa. Nesa coated glass, as the new transparent solid is called, is reported to have good visual properties with electrical conductivity. The product was successfully used during the war in protecting instruments on radar equipment from stray field currents.

Dual Element Fuse. A new dual element fuse which is designed to match the heat absorbing capacity of the protected device has been developed by the Chase-Shawmut Company, Newburyport, Mass.

Miniature Motor. The Alni Corporation, New York, N. Y., is offering a motor, which can operate on 30 milliwatts of power, for application in the radio-electronic field, where a limited source of power is available. The miniature d-c motor can operate in any position and is designed to start in only one direction, regardless of polarity reversal. The motors are manufactured for operation on various voltages and have been used to drive cam-operated switches and small ventilator fans.

Relay in Radio Tube Container. A single pole, double throw, bounce-free d-c relay for use with resistive loads and having an operating time of one millisecond or less has been developed by the Stevens-Arnold Company, South Boston, Mass. The Millisec Relay is assembled in a standard metal radio tube container, but its operation is mechanical and not electronic.

Scale Models for Plant Layouts. Models, scaled $^1/_4$ inch to the foot, of standard or special machines and office equipment are available on short notice from Triometric Engineering Company, Pittsburgh, Pa., for aid in planning plant layouts. By photographing arrangements of these 3-dimensional models comparisons can be made without the expense of time and money required by ordinary methods.

Inexpensive Temperature Controller. Especially designed for those applications where indicating and recording are not required, the Electromax temperature controller has been developed by the Leeds and Northrup Company, Phliadelphia, Pa. Standard ranges for the a-c operated standard vacuum tube instrument are 0 to 250 degrees and 0 to 1,000 degrees Fahrenheit.

Production Wire Stripper. When a wire is inserted between two electrically-heated stripping blades of a new "Hot Blade" wire stripper made by Ideal Industries, Sycamore, Ill., and a foot pedal is depressed, parallel grooves are burned through the insulation down to the conductor. A twist completes the groove and a pull removes the insulation. Strippings fall into a water drawer and a built-in exhaust system removes smoke and fumes.

Water-Cooled Resistor. Developed for television, frequency modulation, and dielectric heating applications, the type *LP* liquid-cooled resistor made by the International Resistance Company, Philadelphia, Pa., is available in values of 35 to 1,500 ohms. Interchangeable intake nozzles permit adjusting the water flow to suit local water pressure and power dissipation up to 5 kw.

Vacuum Capacitor. The *RC100-20*, first in a new line of vacuum capacitors has been announced by the Raytheon Manufacturing Company, Waltham, Mass., for use in high-powered radio-frequency transmitters and industrial oscillators. This new 100-micromicrofarad unit is capable of handling 16,000

(*Continued on page* 26A)

DC
DOW CORNING
SILICONES

VARNISHES
RESINS
FLUIDS
GREASES
SILASTIC*

withstand heat
exclude moisture
resist oxidation

Newspapers are full of stories which imply that American industry is in a critical condition. We disagree and with good reason. We've been developing Silicone products for several years. We are producing them in ever-increasing quantities because these basically new materials will do things no other materials can do. Naturally we have to combat inertia, which is a psychological as well as a physical fact. But we have initiative and enterprise on our side, and we find plenty of both alive in American industry.

Take Automatic Transportation Company of Chicago, for example. All of their new industrial trucks will be powered by DC Silicone Insulated motors lubricated with DC Silicone grease. Automatic Transportation is taking out Silicone insurance against the losses you would suffer if your industrial trucks should break down. With an estimated 20 to 50% of your manufacturing costs going into material handling, that kind of insurance is worth a lot.

Consider the kind of service these industrial trucks get. They may have to lift 1500 or 35,000 pounds. They may be used constantly or only part time. They may run over smooth floors or rough ones. A 2% grade doubles the torque on the motors.

That's why Automatic uses the best insulation there is. They put the best grease they can buy in the bearings. That's DC 44 Silicone grease, because it won't bleed into the windings or brushes. They also cushion the solenoid coils with Silastic*.

Stories like that repeated again and again, prove that American industry is still individualistic, still keen for new and better ways of doing things. The number of inquiries we get for our catalog No. A 1-5 is further proof.

*TRADE MARK, DOW CORNING CORPORATION

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Chicago: 228 N. LaSalle Street • Cleveland: Terminal Tower
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Dow Corning
FIRST IN SILICONES

INDUSTRIAL NOTES....

Small Motor Plant. General Electric Company is turning out small motors at a new plant in San Jose, Calif. Present facilities are in what was formerly an indoor skating rink.

Plant Being Enlarged. The General Radio Company is enlarging its plant at Cambridge, Mass., by addition of approximately 30,000 square feet to the manufacturing space. The new 4-story addition will be used to house operations now being carried on in rented quarters.

Comptroller Retires. John G. Farrar, former comptroller of the General Electric Company, has retired from active service with the company.

Hydroelectric Application. The Federal Power Commission has received an application from the Pacific Gas and Electric Company of San Francisco, Calif., to construct two hydroelectric projects on the North Fork of the Feather River in Butte and Plumas counties. Total capacity of the units is to be 201,000 kva.

Purchasing Agent Appointed. The Philco Corporation, Philadelphia, Pa., has appointed Wilson Oelkers as purchasing agent of the Radio Division and George Hulse as his assistant.

Strike Loss. As a result of the eight-month Congress of Industrial Organizations strike at the Allis-Chalmers Manufacturing Company in West Allis, Wis., total monetary loss in 1946 was $36,484,511. Most of this is attributed to loss of wages, production, and taxes, but $77,200 was the cost of maintaining peace in the picket lines.

New Sales and Service Engineers. The Brown Instrument Company of Philadelphia, Pa., has announced the appointment of 38 new sales and service engineers to 23 of its branches throughout the United States and Canada.

Telegraph Loss. The Western Union Company, New York, N. Y., reported that operations in the first 11 months of 1946 resulted in a deficit of $11,573,084, in contrast with a net income of $3,251,751 for the same 1945 period.

Chief Engineer Appointed. Eugene Frekko was recently appointed to the position of chief engineer of the electrolytic division with headquarters in the laboratory of Cornell-Dubilier Electric Corporation, South Plainfield, N. J.

New Corporation. Eastern Engineering Company, New Haven, Conn., has been consolidated with the Automatic Signal Corporation, East Norwalk, Conn., under the name Eastern Industries, Inc. Personnel of both divisions will remain substantially the same, and the same products will continue to be manufactured.

Name Changed. The Morganite Brush Company, Long Island City, N. Y., has changed its name to Morganite, Inc.

Organization Changes. The General Electric Company Chemical Department, Pittsfield, Mass., announced the appointments of G. P. Lehmann as manager of the plastics division and J. L. McMurphy as manager of the compound division after the former plastics division was reorganized as two separate divisions.

Assistant for Board Chairman. Samuel Insull, Jr., has been appointed assistant to J. S. Knowlson, chairman of the board and president of Stewart-Warner Corporation, Chicago, Ill.

Studios Opened. The Radio Corporation of America Film Recording Department opened enlarged and completely renovated scoring and recording studios in New York, N. Y., recently.

TRADE LITERATURE • • •

Test Instruments. Catalog *129*. 24 pp. A comprehensive line of test instruments including, insulation testers, a-c, d-c vacuum tube volt-ohm capacity meters, signal generators, volt-ohm milliammeters, tube and set testers, square-wave generators, and allied test equipment are described. Radio, Electrical and Electronic Test Instruments. Copies of the catalog can be obtained from authorized Radio City Products Company, Inc., jobbers or by writing direct to the company at 127 West 26th Street, New York 19, N. Y.

Transformers for Secondary Banking. Booklet *B-3777*, 12 pp. Explains, with the help of schematic diagrams, how the CSPB transformer clears faults, indicates tripped circuit breakers, and gives load indication. The transformer is completely self-protected, and contains a circuit breaker in addition to the one required for thermal protection. Westinghouse CSPB Transformers for Secondary Banking. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

Control Apparatus. Bulletin *504*, 4 pp. Electronic timers, level controls, electronic pilot relays, smoke controls, photoelectric controls, and registration controls are described in this bulletin. Photoswitch. Photoswitch, Inc., Cambridge, Mass.

Reproduction Process. Booklet, 4 pp. Describes Kodak Transfax, a reproduction process for use with metals, plastics, and plywood or pressed woods. Explains the steps in using the light-sensitive Transfax solution for transferring working diagrams, legends, designs, or other line work from drawing to material. Kodak Transfax. Eastman Kodak Company, Industrial Sales Division, 343 State Street, Rochester 4, N. Y.

Fire Protection. Data guide. Presents important facts about the suitability, maintenance, and performance of soda-acid, foam, pump tank, dry powder, loaded stream, carbon tetrachloride, and carbon dioxide fire extinguishers. Also presents installation data. DATA-GUIDE. Randolph Laboratories, Inc., 8 East Kinzie Street, Chicago 11, Ill.

Farm Wiring. Booklet *B-3874*, 44 pp., 25 cents. Charts are provided from which give direct readings of wire size required for a given voltage drop, current, and length of circuit. Diagrams and tables supply recommendations as to the number of circuits, location and spacing of lighting, and convenience and heavy duty outlets according to farm enterprises which include: dairy, poultry, shop and machinery shed, crops, water supply, and home. Farmstead Wiring Booklet. Available from distributors of the Westinghouse Electric Corporation, East Pittsburgh, Pa.

Manual Planning. Booklet, 24 pp. Valuable suggestions on what to include in an "owner manual" and how to present the material in the most effective way are given. Included are sample pages of sectional and cutaway views, flow diagrams, tune-up and maintenance illustrations, trouble charts, and exploded parts views. The Kenco Teck Guide also is designed to be used as a work book with space for filling in and laying out information that would apply to the user's product. How to Plan an Owner Manual. Ken Cook Company, 710 North Plankinton Avenue, Milwaukee 1, Wis.

Terminology. Booklet, 12 pp. To overcome the difficulties arising from the distinctive terminology used in the plastics and rubber industry, a glossary of terms, names, and phrases has been prepared. The booklet is designed to give manufacturers, fabricators, and designers a knowledge of words associated with the production and application of plastics and nitrile rubbers. Rubber and Plastic Terminology. B. F. Goodrich Chemical Company, 324 Rose Building, Cleveland 15, Ohio.

Arnold presents:

another step towards a complete line of permanent magnet materials . . . . .

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CAST ALNICO I

CAST ALNICO II

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CAST ALNICO XII

SINTERED ALNICO

In general SINTERED ALNICO MAGNETS do not compete with, but rather supplement, magnets produced by the cast method to widen the scope of potential permanent magnet applications.

Alnico magnets weighing roughly one ounce or less should be produced by the sintered method.

Heavier magnets of more intricate shapes can be produced. For some applications Sintered magnets are more economical because:

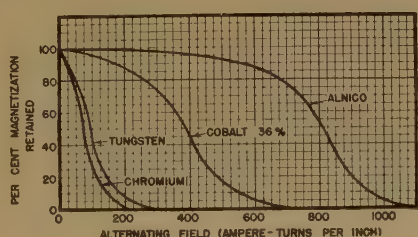
1. Magnetic characteristics are practically the same as Cast Alnico.
2. Sintered Alnico is a fine-grain, homogeneous material which has more uniform flux density, is easier to grind, and provides better surface finish.
3. Sintered Alnico magnets can be produced to closer dimensional tolerances:

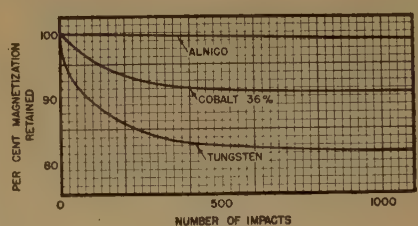
SINTERED ALNICO II	CAST ALNICO II
0.000 to 0.125 — + .005	0.000 to 2.00 — ± 1/64
0.126 to 0.625 — + .010	2.0 to 4.0 — ± 1/32
0.626 to 1.250 — + .015	4.0 to 6.0 — ± 3/64
1.251 to 3.000 — + .062	

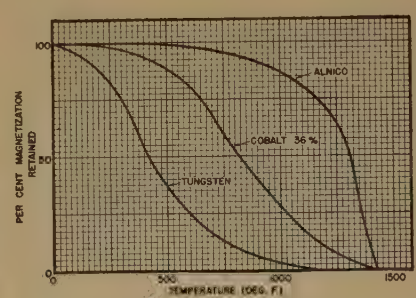
   Grinding can in many applications be eliminated.
4. More intricate shapes, including holes, inserts, etc., are more feasible.
5. Transverse modulus of rupture is several times greater.

All Alnico, and particularly Sintered magnets, have very high values of Coercive Force (which is the capability of resisting demagnetization or loss of magnetism due to stray fields and from heat and vibration).

The curves show roughly the effect of these demagnetization factors on Alnico compared to other alloy steels.







THE ARNOLD ENGINEERING COMPANY

SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION

147 EAST ONTARIO STREET, CHICAGO 11, ILLINOIS

Specialists in the manufacture of PERMANENT MAGNET MATERIALS

INDUSTRIAL NOTES....

Manager for Radio Division. Frank H. Barnett is the new manager of manufacturing at the Home Radio Division of the Westinghouse Electric Corporation at Sunbury, Pa.

Diesel-Electric Development to Continue. The American Locomotive Company, New York, N. Y., is prepared to manufacture Diesel-electric locomotives by mass methods, according to President R. B. McColl. He said that the company has expended $20,000,000 in research and development leading up to its new line of Diesels.

New Plant. Hexacon Electric Company, Roselle Park, N. J., has completed a new addition to the factory where industrial soldering irons are manufactured.

Sales Manager Assigned. H. A. Crossland has been assigned as sales manager of the General Electric Company electronics department specialty division at Syracuse, N. Y.

Vice-President Elected. E. R. Godfrey, manager of the Frigidaire Division, Dayton, Ohio, recently was elected a vice-president of General Motors Corporation, Detroit, Mich. Mr. Godfrey will continue in his position at Frigidaire.

Antifriction Bearings. There is an increased demand for additional ball and roller bearings in household appliances and electric and power equipment according to a statement by the Anti-friction Bearing Manufacturers Association.

Long-Life Fluorescent Lights. The Duro Test Corporation, North Bergen, N. J., has patented a new type cathode which is expected to double the life of fluorescent lights. Life of a fluorescent lamp is dependent on the length of life of the cathode emission coating. The new invention provides two or more cathodes at each end of the fluorescent lamp and the use of a switching mechanism for successively rendering the cathodes active as previously active cathodes becomes exhausted by the deterioration of emission coating.

Sales Section Manager. M. F. Slusser has been made manager of the construction and communications section of the industrial sales department of Westinghouse Electric Corporation, East Pittsburgh, Pa.

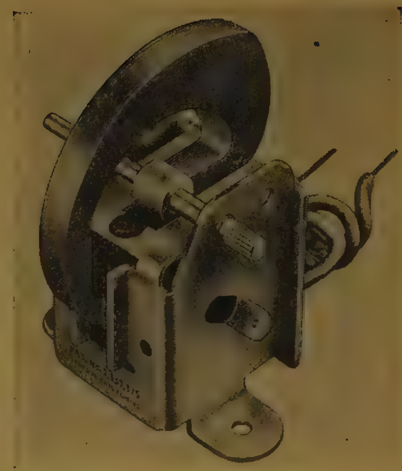
Research Center Under Construction. Facilities for chemical and physical research will be contained in two new buildings of the Johns-Manville Research Center near Bound Brook, N. J., which is near the main plant at Manville, N. J. The first unit is nearing completion and will be in use the early part of this year.

NEW PRODUCTS...

Constant Voltage Tube. Philips Laboratories, Inc., New York, N. Y., have developed voltage-stabilizing tubes of the glow discharge type in which working voltage is independent of the current over a wide range. The improvement was accomplished by use of a carefully prepared molybdenum cathode and a thick layer of molybdenum deposited on the walls of the tube by sputtering. In the new tube ambient temperature has but little effect on the voltage.

Electronic Contactor. For resistance welders involving exceptionally high-speed operation or heavy primary currents of short duration, a new electronic contactor is being offered by Square D Company, Industrial Controller Division, Milwaukee, Wis. Ignitron tubes are used in the unit which is to supplement the Syncro-Break and high-speed magnetic contactors.

Kilovoltmeter. Both a-c–d-c and d-c meters are available for measurements up to 20 kv in a new series of instruments manufactured by Shallcross Manufacturing Company, Collingdale, Pa. The instruments have a sensitivity of 10,000 ohms per volt and accuracy is within two per cent for d-c measurements and five per cent for a-c measurements.



Rotary Solenoid. A unique power device developed by Radio Condenser Company, Camden, N. J., operates as a solenoid except that it rotates through 180 degrees, thereby producing torque instead of thrust, consequently eliminating the need for connecting linkages. The Rotonoid, as the device is called, is approximately $2^1/_2$ by $2^5/_8$ by $3^1/_4$ inches, weighs 10 ounces, and produces a 16-inch-ounce torque operating 20 cycles per minute on 60-cycle 115-volt alternating current.

TRADE LITERATURE...

Insulation Manufacture. Booklet, 20 pp. Illustrates various steps in the manufacture of electrical insulation and lists factors considered in the manufacture of coated fabrics and paper, varnished sleeving and tubing, and extruded tubing. "How Electrical Insulation Is Made." The National Varnished Products Corporation, 211 Randolph Avenue, Woodbridge, N. J.

Temperature Controls. Bulletin 5, 20 pp. Charts, tables, and diagrams explain measurement, automatic control, and selection of proper control systems for process applications. American Society of Mechanical Engineers terminology referring to processes and automatic control is included. "Automatic Temperature Control Systems." Wheelco Instruments Company, Chicago 7, Ill.

Turbine Maintenance. Booklet *B-3747*, 96 pp. Description, operation, and installation information is given, and directions for piping, joint sealing, and lubricating are included. The final chapter presents hints for determining improper operation. "Maintenance Hints for General Purpose Turbines." Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

Time

Time is the measure of all things. Few of man's inventions can stand its merciless judgment. Yet Kerite for over 90 years has thrived and spread and gained renown. Time, indeed, gives Kerite its unqualified recommendation.

THE KERITE COMPANY

NEW YORK CHICAGO SAN FRANCISCO

PIONEERS IN CABLE ENGINEERING

TRADE LITERATURE....

Silicones. Catalog, 12 pp. The unique properties of silicones are described in the third edition of this catalog. Charts, graphs, and tables listing products of the rapidly increasing family of organo-silicon-oxide polymers are presented. "New Engineering Materials." Dow Corning Corporation, Midland, Mich.

Chlorinated Rubber. Booklet, 32 pp. Describes Parlon, a chlorinated rubber product which before the war was used widely as a base in paints for concrete and other surfaces exposed to action of chemicals, gases, moisture, mold growths, and other destructive agents. The booklet is divided into sections on properties and uses. "Parlon." Hercules Powder Company, Inc., Wilmington 99, Del.

Insulating Varnishes. Booklet, 40 pp. Includes specifications and properties of 36 grades of varnishes for baking and air drying. "Insulating Varnishes." Resin and Insulation Materials Division, Chemical Department, General Electric Company, Pittsfield, Mass.

Film Storage. Pamphlet, 16 pp. Discusses protection required, classification, types of storage, and preparation for storage of safety film and paper base material only. Recommendations are based on laboratory tests and experience. "Storage of Microfilms, Sheet Films, and Prints." Eastman Kodak Company, Rochester 4, N. Y.

Renewable Fuses. Folder *206-A*, 24 pp. Drawings and charts help to show the powder-packed principle in renewable fuse design. A section of questions and answers is included. "The Inside Story of Trico Renewable Fuses." Trico Fuse Manufacturing Company, 2958 North 5th Street, Milwaukee 12, Wis.

Insulation Saturants. Booklet, 16 pp. Describes chemical, physical, and electrical properties of saturants suitable for treating fibrous materials used in insulating electric wire and cable. Lists some principal applications. "Zyrox." Bakelite Corporation, 300 Madison Avenue, New York 17, N. Y.

Askarel Transformers. Bulletin *1246*, 8 pp. Summarizes some of the main features of distribution and power size noninflammable liquid-filled transformers. "Ask for Askarel." Pennsylvania Transformer Company, 808 Ridge Avenue, Pittsburgh 12, Pa.

Flexible Couplings. Bulletin *4100*, 32 pp. Presents illustrations and descriptions of Steelflex couplings. Simplified selection tables are provided for both motor and turbine applications. "Falk Steelflex Couplings." The Falk Corporation, 3001 West Canal Street, Milwaukee 8, Wis.

Betatron. Bulletin, 4 pp. Describes the recently developed 20-million-electron-volt X-ray machine. Operation is explained by text and diagrams, and numerous industrial applications are listed. "Betatron." Allis-Chalmers Manufacturing Company, Milwaukee 1, Wis.

NEW PRODUCTS •••

Paper Shielding. Elimination of the usual supplementary metal shield over insulated conductors has been found possible by the use of a new metallized-paper shielding tape now being produced by Keller-Dorian Corporation, New York, N. Y., for use in oil-impregnated paper-insulated cables.

Discharge Capacitors. Solar Manufacturing Corporation, New York, N. Y., has announced a new series of energy storage capacitors for lighting applications, high-intensity flashing display signs, beacons, capacitor-discharge welding, and so forth. The new Solar Type *QLX* series of discharge capacitors are claimed to have an excellent energy-storage-to-weight ratio.

Resistance Heating Soldering Tool. The Thermo-Grip soldering tool, manufactured by Ideal Industries, Inc., Sycamore, Ill., has been completely redesigned. The complete unit includes a transformer or power unit and a soldering tool that operates like a pair of pliers. Holding the work with the pliers completes the transformer secondary circuit and causes instantaneous heating between the jaws. Other tools included in the line are pencil and fork types.

Geiger-Müller Tubes. A beta-ray tube and a gamma-ray tube suitable for a wide range of laboratory and industrial applications concerned with nuclear physics have been announced by Sylvania Electric Products, Inc., New York, N. Y. The gas-filled tubes are of the non-self-quenching type and are intended for use with a standard quenching circuit such as the Neher-Pickering. When utilized with suitable auxiliary apparatus, the tubes detect radiations emitted by radioactive substances, and the intensity of radiation is measured by the tube counting the number of particles reaching it in a given period.

Safety Starter. A new fluorescent lamp starter cuts off the current from the unit, and prevents overheating and damage to the ballast when the defective tube has reached the end of its service life and flickers or blinks. After the defective lamp is replaced the lockout-reset starter automatically resets and lights the lamp. The Bakelite housed unit is manufactured by Lloyd Products Company, Providence, R. I.

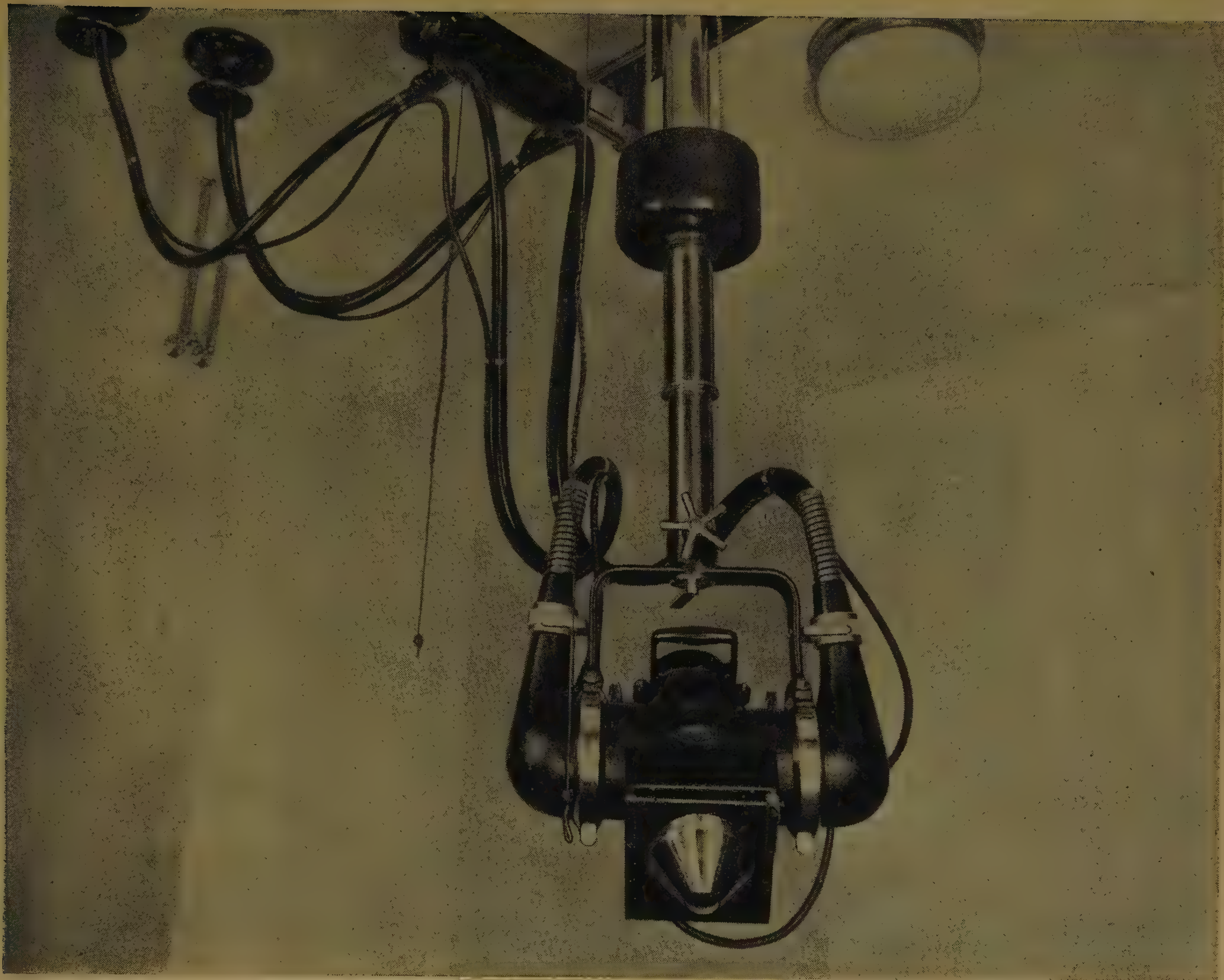
Electronic Servomechanism. The Motron servomechanism Model *61A* made by W. C. Robinette Company, South Pasadena, Calif., is a packaged continuous-balance control system of practical infinite sensitivity. Several miniature vacuum tubes directly control the speed and direction of a 1/15-horsepower induction motor which can be used to control larger power units. The input dial may be actuated by small forces, such as produced by electric meter pointers, pressure gauge pointers, magnetic compass needles, air vanes, or other small devices.

INDUSTRIAL NOTES • • •

Catalog Service. United States manufacturers are to have a new means of keeping information accessible in the offices of potential South American customers. An industrial catalog service patterned after Sweet's Files which serve domestic markets will be compiled and issued by Editorial Golova, Buenos Aires, Argentina, one of the best known publishers of technical and business magazines in South America.

New Sales Section. Formation of a new section to market electron tube mounts and accessories headed by W. F. Barnes as manager has been announced by Victor Division, Radio Corporation of America, Camden, N. J.

Manufacturing Plant Added. A plant in Fall River, Mass., with 250,000 square feet of floor area has been purchased by Jefferson Electric Company, Bellwood, Ill., to facilitate production and delivery of its line of transformers, ballasts, and fuses.



Kerite insulation withstands the dielectric stress and constant flexing of commercial x-ray use.

The Cable Nobody Could Build

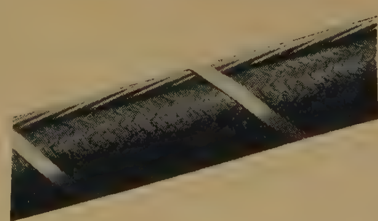
CABLE insulation takes a beating in commercial x-ray service. It is subjected to constant flexing at short radius, under high voltage stress, and over a wide temperature range. For years, x-ray cable failures were common occurrences until the problem was given to the engineers of the Kerite Company.

The answer was found with the first lengths of Kerite x-ray cable manufactured. Today Kerite cable is standard equipment on many x-ray machines.

Perhaps *your* cable problem can be solved by Kerite-insulated cable. It costs nothing to find out. Kerite-insulated wire and cable is made for a wide variety of power and signal-system applications. Ask any Kerite user about its remarkable stamina and low cost per year. *The Kerite Company, 30 Church Street, New York 7, N. Y.*

Offices also at: 122 S. Michigan Ave., Chicago 3; 582 Market St., San Francisco 4; 714 W. Olympic Blvd., Los Angeles 15.

Kerite Aerial Cable



Kerite factory-assembled aerial cable saves installation time, eliminates tree trimming, stands up under severe ice conditions.

Kerite Insulation—Your Cable's Best Life Insurance

DAYS KERITE

KERITE CABLE

INDUSTRIAL NOTES....

Utilities to Expand. The Consolidated Gas and Electric Company, Baltimore, Md., plans to spend up to $50,000,000 by 1949 for construction and equipment. Connecticut Power Company plans include a steam power plant at Stamford to cost $6,000,000. Construction will begin soon for a steam generating plant in West Springfield, Mass., for the Western Massachusetts Electric Company.

New Chief Radio Engineer. Garrard Mountjoy, former president of Electronic Corporation of America, has joined the Stromberg-Carlson Company, Rochester, N. Y., engineering staff as chief radio engineer.

New Sales Office. Sola Electric Company, Chicago, Ill., has opened a new sales office with factory-trained personnel at 50 Church Street, New York 17, N. Y.

Name Change. Schweitzer and Conrad, Inc., Chicago, Ill., in the interests of simplification, has changed its name to S & C Electric Company. The change has no significance as regards personnel or ownership.

California Site Purchased. Owens-Corning Fiberglas Corporation, Toledo, Ohio, has purchased a 42-acre site in Santa Clara, Calif., to construct a $7,000,000 plant which will employ several hundred workers.

New Appliance Manufacturer. The Yale and Towne Manufacturing Company, New York, N. Y., hardware and industrial equipment manufacturing organization, has entered into the appliance field with a new type electric iron. Major feature of the new iron is an articulated sole plate.

General Electric Shows Income Drop. In its 55th annual report the General Electric Company, Schenectady, N. Y., showed a net income of $43,039,589 for 1946, a decrease of 24 per cent from the $56,540,555 earned the year previously.

Power Tubes to Be Made. National Electronics, Inc., Geneva, Ill., recently completed installation of facilities for production of industrial electronic tubes, and is specializing in the gaseous rectifier and thyratron field. This company was formed in 1945 as a split-off from Continental Electric Company, also of Geneva.

Service Facilities Transferred. The Foxboro Company, Foxboro, Mass., recently announced that all its facilities for servicing Horn tachometers have been acquired by the James G. Biddle Company, Philadelphia, Pa.

Golden Anniversary Celebrated. The Kellogg Switchboard and Supply Company, Chicago, Ill., marked its 50th anniversary on April 28, 1947.

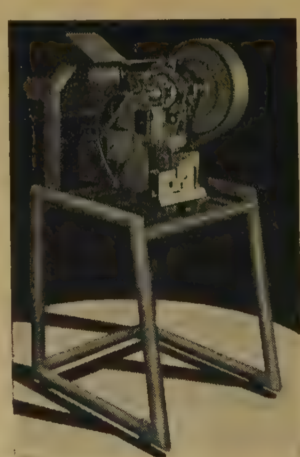
New Chief Telephone Engineer. R. W. Engsberg was recently appointed chief telephone engineer of Federal Telephone and Radio Corporation, Newark, N. J., manufacturing associate of International Telephone and Telegraph Corporation, Clifton, N. J.

NEW PRODUCTS...

Variable Inductance. P. R. Mallory and Company, Inc., Indianapolis, Ind., has announced a new patented unit for providing infinitely variable inductance facilities for tuning all television, frequency modulation, and other stations from 44 to 216 megacycles within the range of the receivers. This entire band is covered in 3,600 degrees rotation (10 turns) of the shaft, which may be hand or motor driven.

Fabrication Wax. The Sun Oil Company, Philadelphia, Pa., announced recently a new product, Sunwax *1290*, which is a relatively hard, nonbrittle, nonsticky, petroleum wax of the microcrystalline type. Melting point of the wax is 175 degrees Fahrenheit. Extensive use is expected to be found for it in the fabrication of electronic coils and paper-wrapped capacitors.

Automatic Electric Connectors. A continuous strip of terminals and a completely automatic crimping cycle to achieve production speeds in excess of 3,300 perfect identical electric connections per hour, are utilized in this AMP automatic machine. Continuous strip solderless terminals are available in many sizes and shapes from the manufacturer of the machine, Aircraft-Marine Products, Inc., Harrisburg, Pa.



Metal Cut With Electric Arc. Equipment has been developed to provide a new method for hand cutting or piercing stainless and alloy steel, aluminum, bronze, brass, and various other metals through utilization of a stream of oxygen in an electric arc. The equipment is claimed to be useable in any position and is reported to cut metal in any desired shape. The process was perfected by the Arcos Corporation, Philadelphia, Pa.

A-C Load Visualizer. The *AF-1* a-c load visualizer is an analyzer for use on single-phase and balanced polyphase systems, and serves as a standard 0–2.5/5 ampere ammeter and a 0–150/300/600-volt voltmeter. By using the instrument with a furnished calculator, watts, vars, volt-amperes, and power factor for load surveys, induction motor tests, reactive power studies, and power factor checks on power and lighting circuits can be made. The instrument is made by the General Electric Company, Schenectady, N. Y.

TRADE LITERATURE...

Graphical Symbols. ASA publication *Z32.5*, 20 pp. A limited supply of complimentary copies of American Standard "Graphical Symbols for Telephone, Telegraph, and Radio Use" is available from: Solar Manufacturing Corporation, 285 Madison Avenue, New York 17, N. Y.

Contact Material. Catalog *12*. Describes silver-graphite and silver-tungsten contacts. Stackpole Carbon Company, St. Marys, Pa.

Thermally Sensitive Resistors. Brochure, 18 pp. Summarizes design principles and characteristics of thermally sensitive resistors. Includes a tabulation of existing and potential applications. Western Electric Company, 195 Broadway, New York 7, N. Y.

Solderless Wiring. Book, 28 pp. Displays the various types of solderless terminals, and features their applications in a series of illustrated charts index-tabbed for ready reference. Aircraft-Marine Products, Inc., 1536 North Fourth Street, Harrisburg, Pa.

Carbon Brushes. Booklet, 36 pp. Includes information on brush characteristics, brush grades, service recommendations, brush standards, definitions, shunt locations, installation hints, and how to specify brushes. "Spear Carbon Products." Spear Carbon Company, St. Marys, Pa.

Thermostat Data. Catalog, 54 pp. The selection and application of Thermoswitch controls section of the catalog treats temperature control fundamentals, temperature variation, lag and overshoot, characteristics of heat sources, process characteristics, and details of thermoswitch controls. "Fenwal Thermoswitch Controls," Fenwal, Inc., Ashland, Mass.

Illinois U Library

ELECTRICAL ENGINEERING

Registered United States Patent Office

JUNE 1947

The Cover: Concentrated phosphor solution is poured into a rotating glass funnel to deposit the screen face of the cathode-ray tube used in television.
North American Philips Company, Inc., photo

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VOLUME 66
NUMBER 6

Statements and opinions given in articles and papers appearing in *Electrical Engineering* are the expressions of contributors, for which the Institute assumes no responsibility. ¶ Correspondence is invited on all controversial matters.

Published Monthly by the

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Founded 1884

J. ELMER HOUSLEY, President — H. H. HENLINE, Secretary

PUBLICATION COMMITTEE: C. F. Wagner, *chairman*; R. K. Honaman, B. M. Jones, F. A. Lewis, J. R. North, J. J. Orr, M. S. Coover, H. H. Race, H. H. Henline, G. A. Van Brunt

Electrical Engineering: Copyright 1947 by the American Institute of Electrical Engineers; printed in the United States of America; indexed annually by the AIEE, weekly and monthly by *Engineering Index*, and monthly by *Industrial Arts Index;* abstracted monthly by *Science Abstracts* (London). Address changes must be received at AIEE headquarters, 33 West 39th Street, New York 18, N. Y., by the first of the month to be effective with the succeeding issue. Copies undelivered because of incorrect address cannot be replaced without charge.

Where there is Horsepower...

There is Wire

What has happened to transportation? A little over a hundred years ago Napoleon "sped" from Moscow to Paris at approximately 3 miles per hour. Today we talk of speeds of a thousand miles per hour.

Belden Manufacturing Company in its life of 40 years has witnessed and served a "transportation revolution." In that brief time, the automobile, the airplane, the diesel-electrics, and now the rockets, have taken their place in our living. All of these were made possible when wild horsepower ran into a trap of wire—and when other specialized products of the wiremakers served the inventors of our modern power.

Belden WIREMAKER FOR INDUSTRY

QUESTION: What does "Self-Supporting" mean when applied to aerial cable?

ANSWER: It is an insulated power cable design that includes a messenger wire as an integral part of the assembly. It may contain one or more insulated conductors.

QUESTION: What *improvements in service* are gained through the use of such a cable?

ANSWER: It is designed to supplant open-wire construction by providing a fully-insulated cable that eliminates tree-trimming, reduces service interruptions, improves current regulation, cuts down pole congestion and reduces the clearances normally needed near structures.

QUESTION: What are some of the *economies* of Okolite-Okoprene Self-Supporting Aerial Cable?

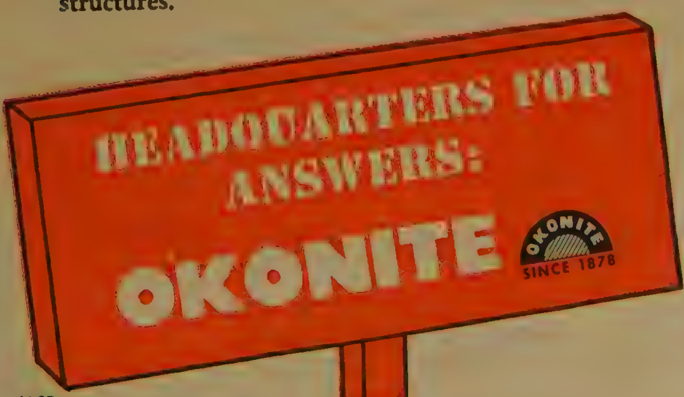
ANSWER: It can be installed in a *single operation* requiring no separate stringing of messenger or placing of rings, it permits long spans, doesn't need over-length poles to clear tree tops, can operate in storms and even when poles are down.

QUESTION: What are some of the *unique features* of Okolite-Okoprene Self-Supporting Aerial Cables?

ANSWER: It does not require a lead sheath yet is permanently weather-protected with its Okoprene covering; it can be spliced by any lineman, does not require shielding up to 5000 volts and, when furnished with "Dualay" assembly is the *only self-supporting cable that can be tapped hot.*

QUESTION: How can I find out more about Okolite-Okoprene Self-Supporting Aerial Cable and its relation to my own distribution problems?

ANSWER: (1) By talking with Okonite engineers or (2) sending for the new 52-page manual on Self-Supporting Cable which contains complete engineering information, charts, tables, photographs, diagrams. Just ask for Bulletin OK-1033 when writing to The Okonite Company, Passaic, N. J.



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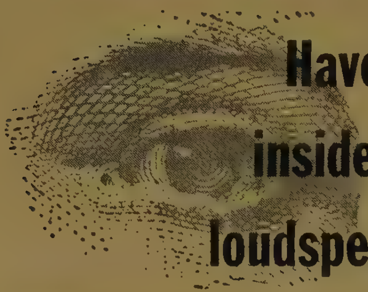
PERMANENT MAGNETS MAY DO IT BETTER



Have you looked inside your loudspeaker lately?

Let's look into the busy end of your radio . . . into the part that does the talking. The loudspeaker owes much of its fine, full, clear tone quality to the magic aid of the permanent magnet. Particularly in the construction of FM radios, where the finest acoustical quality attainable is desired, permanent magnet speakers are proving their excellence. The widespread popularity of permanent magnet speakers is well demonstrated by production records. Over 12 million speaker magnets such as those shown below have been made by *The Indiana Steel Products Company* since World War II.

©1947, The Indiana Steel Products Co.

Why you should have a Permanent Magnet Loudspeaker in your radio

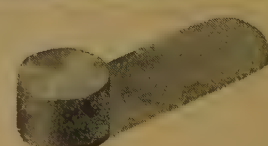
Both in radio design and performance the use of Permanent Magnet Speakers offers many advantages:

1. **They permit greater flexibility in design.**
2. **They reduce service problems.**
3. **They generate no heat.**
4. **Maximum energy with minimum size and weight is attained with Alnico V.**
5. **They reduce power input—of vital importance in automobile radios. They avoid drain on car battery.**

"THE FUTURE IS SOUND"

World War II brought many technological advances. New materials now make possible magnet designs which were formerly impractical. ALNICO V, undoubtedly the best known example, is now used almost universally in the manufacturing of speaker magnets.

Watch for INDALLOY.



Investigate the use of permanent magnets in your radio speaker. As the largest producer of permanent magnets for loudspeaker use, *The Indiana Steel Products Company* offers you an exceptional permanent magnet engineering design service . . . complete from plan to finished product. Versatile in finding the most practical solution to your magnet problem, whatever it may entail, our engineers welcome the opportunity to be of assistance.

★ **THE INDIANA STEEL PRODUCTS COMPANY** ★

PRODUCERS OF "PACKAGED ENERGY"
6 NORTH MICHIGAN AVENUE • CHICAGO 2, ILL.

ISP

SPECIALISTS IN PERMANENT MAGNETS SINCE 1910
PLANTS { VALPARAISO, INDIANA
STAMFORD, CONN.

NEW NEW NEW NEW NEW NEW NEW NEW NEW

QUICK { TRIP MAKE BREAK THERMAL-Coilless MAGNETIC CIRCUIT BREAKER

Type ML A.C./D.C. 1, 2, or 3 Pole, 15 to 50 Amperes for Direct or Alternating Current Systems

1. Mechanism is completely enclosed in a sealed, compact, molded bakelite case to prevent tampering
2. Narrow slot for edgewise contact arm isolates arc chamber
3. Arc chamber vent screen
4. Arc suppressor chamber
5. Arc suppressor stack especially designed to instantly rupture both direct and alternating currents
6. Silver tungsten contacts brazed to contact arms and plates
7. Bearing surfaces are hardened to reduce wear
8. Stainless steel sensitive latch
9. *Coilless* magnetic trip element
10. Terminal screw for lower ampere ratings
11. Main spring (concealed) provides positive contact pressure and strong mechanism action
12. All-steel parts are rust-proofed to prevent corrosion
13. Sealed bimetal adjustment screw
14. Bimetal for delayed trip
15. Solid, high strength, high conductivity cadmium copper edgewise contact bar
16. Strong cross section molded bakelite handle

This new and vastly superior Square D thermal-magnetic breaker has a unique *coilless* magnetic tripping mechanism which causes it to open instantly on moderate as well as heavy short circuits. A quick-make and quick-break mechanism of simple and rugged construction is incorporated in this breaker to assure long life and trouble-free service.

New lines of lighting panelboards, also general purpose industrial service equipment enclosures, using these new breakers, are now available for delivery.

The ML A.C./D.C. breakers are designed for use on either direct or alternating current systems where 1, 2, or 3 pole circuits are required. They are ideal for motor or branch circuit wiring.

Features

- HOLDS MOMENTARY OVERLOADS (thermal trip)
- TRIPS FAST ON SHORT CIRCUITS (*coilless* magnetic trip)
- QUICK-MAKE, QUICK-BREAK (manual operation)
- QUICK-BREAK (automatic operation)
- MEETS FEDERAL SPECIFICATION WP131A FOR CLASS 1 BREAKERS

Write **for Information on ML A.C./D.C. Breakers.**
Square D Company, 6060 Rivard St., Detroit 11, Michigan.

SQUARE D COMPANY

DETROIT • MILWAUKEE • LOS ANGELES

In Canada: SQUARE D CANADA, LTD., TORONTO, ONT. • *In Mexico:* SQUARE D de MEXICO, S.A., MEXICO CITY, D.F.

MEN WHO KNOW MOST ABOUT

O-B PINTYPES

---Continue to Make Them Their

CHOICE OF INSULATORS

MANY Power men have lived very close to these O-B pintypes for a long time--20 to 30 years, or more--and don't have to look beyond their own records or their own experience when it comes to making a choice of insulators... It is significant that the systems represented by these lines are among the most loyal and continuous users of O-B pintypes... Men who are in position to know *most* about them--on their own terms--make O-B their CHOICE OF INSULATORS!

2777-H

Ohio Brass

MANSFIELD, OHIO

CANADIAN OHIO BRASS CO., LTD., NIAGARA FALLS, ONTARIO

HEADQUARTERS FOR PORCELAIN INSULATION

Recent Stackpole developments have been signally successful in bettering fractional horsepower motor brush performance—even when no trouble existed and where the only problem was the ever-present one of making sure you get the best brushes for your money.

We prefer to make brush recommendations on the basis of tests of the actual equipment under simulated working conditions in the Stackpole Brush Testing Laboratories. Experience has proved we can serve brush users best by this scientific approach to a matter all too often handled by rule-of-thumb methods. Why not let us check your brushes on this basis—with the responsibility being Stackpole's to PROVE that better brushes can be obtained?

STACKPOLE CARBON COMPANY, ST. MARYS, PA.

STACKPOLE

BRUSHES and CONTACTS (All carbon, graphite, molded metal and composition types)—RARE METAL CONTACTS • SINTERED ALNICO II
WELDING CARBONS • CHEMICAL CARBONS • CARBON SPECIALTIES
PACKING, PISTON and SEAL RINGS • CONTINUOUSLY ADJUSTABLE CARBON RHEOSTATS • SPECTROGRAPHITE NO. 1, etc., etc.

The two filters in the picture (one with side cut away) are used to separate two radio channels coming in on the same antenna but on different frequencies. At the end of the connecting waveguide, the channels are made to part company, each going to a different circuit through its assigned filter.

SEPARATION CENTER
FOR RADIO WAVES

Thirty years ago, when all telephone service went by wire, Bell scientists developed means of sending dozens of conversations over the same line.

This they did by giving to each conversation a different *carrier frequency;* then to separate it from the others, they used a device which they had invented and named—the *electric wave filter.*

Today, in microwave telephone systems, the message-bearing waves pass to and from the antenna in pipes called waveguides. So scientists in Bell Laboratories devised a different kind of filter — a filter in a waveguide. This filter is a system of electrically resonant cavities formed by walls and partitions. Waves that set up sympathetic vibrations in the cavities pass through; others are reflected.

In the Bell System, now, single circuits are carrying many conversations at the same time through precision wave-filtering.

BELL TELEPHONE LABORATORIES

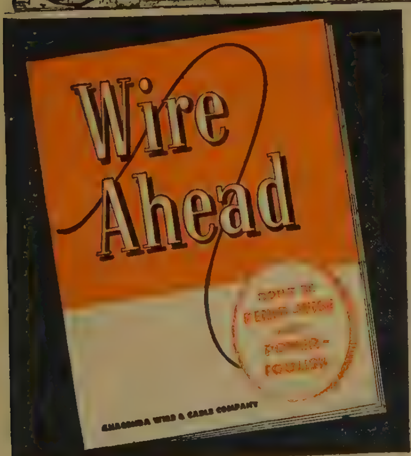
EXPLORING AND INVENTING, DEVISING AND PERFECTING, FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE

Arrest this Thief!

INADEQUATE WIRING, the industrial jinx, can rob any plant large or small . . . of as much as 25 to 50 percent of rated efficiency. And what's most discouraging, the greater the production load, the deeper he digs into your resources.

Obsolete, overextended, overtaxed wiring may be difficult to detect, but it's too expensive to ignore. You may not be able to see this demon, but your plant power engineer, your consulting engineer, electrical contractor, or utility power salesman can. A little policing now may save expensive alterations later.*

47449



*WIRE AHEAD, a new booklet discussing preventive maintenance . . . the symptoms of inadequate wiring . . . and presenting plans for anticipating electrical demand, is now in preparation We shall be glad to send it on request as soon as it is available. Address Advertising Department, 25 Broadway, New York 4, N. Y.

ANACONDA
from mine to consumer

ANACONDA WIRE AND CABLE COMPANY

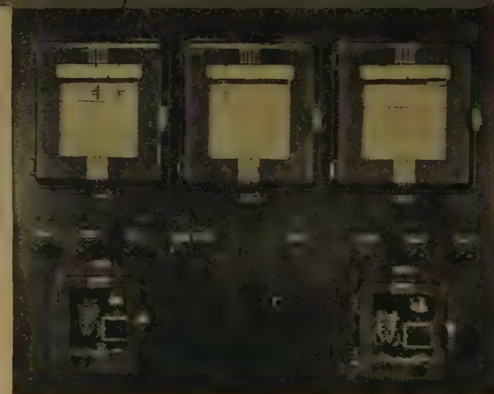
REALIZATION of a System's Potential Economy is Largely in the Dispatcher's Hands

The system economy which a load dispatcher customarily maintains—and which is his regular responsibility—can be increased very substantially by giving him two automatic "tools" for his work.

One tool is a Micromax Load Recorder or Recorders to show load conditions promptly and continuously. The other tool is L&N Automatic Load-Frequency Control, to carry out the dispatcher's orders.

Approximately 1/100 of 1 per cent—or the order of twenty-five hundred dollars out of 25 million—of the total capital invested in a power system, will give its dispatchers this equipment. The installation is even more advisable when one recalls that the dispatchers are largely responsible for operation of the major equipment which represents a big share of the total investment.

This is just one reason why systems totaling more than 35,000,000 kw capacity now use these L&N instruments. At your request, an L&N engineer will be glad to sit down with you and explain, or to send Technical Publication N-56-161(1), as you may prefer.



L&N Load Recording and Load Frequency Controlling Panels. Above—for a Public Utility; below—for a Steel Mill.

LEEDS & NORTHRUP COMPANY, 4962 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

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The Kidde Manufacturing Co., Inc., Bloomfield, N. J., designed an ingenious kit for physicians which made dry ice from carbon dioxide cartridges in a convenient, pencil-shaped applicator. Kidde asked General Electric to produce the apparatus in plastics that would withstand the −60 degrees F temperature of dry ice. Since the individual parts had to fit together precisely, the molding operation required unusual engineering skill. The final result met the high standards of the customer and of the medical profession—and provided another example of how General Electric successfully applies plastics to meet the special requirements of an unusual job.

When you think of plastics, think of General Electric, world's largest manufacturer of finished plastics products. Write for the free full-color booklet, "What Are Plastics?" Address E-15, Plastics Division, Chemical Department, 1 Plastics Avenue, Pittsfield, Mass.

G-E Complete Service—Everything in Plastics

BACKED BY 53 YEARS OF EXPERIENCE. We've been designing and manufacturing plastics products ever since 1894. G-E research works continually to develop new materials, new processes, new applications.

NO. 1 PLASTICS AVENUE—complete plastics service—engineering, design and mold-making. Our own industrial designers and engineers, working together, create plastics parts that are both scientifically sound and good-looking. Our own toolrooms are manned by skilled craftsmen—average precision mold experience, 12 years.

ALL TYPES OF PLASTICS. Facilities for compression, injection, transfer and cold molding . . . for both high and low pressure laminating . . . for fabricating. And G-E Quality Control —a byword in industry—means as many as 160 inspections and analyses for a single plastic part.

EVERYTHING IN Plastics

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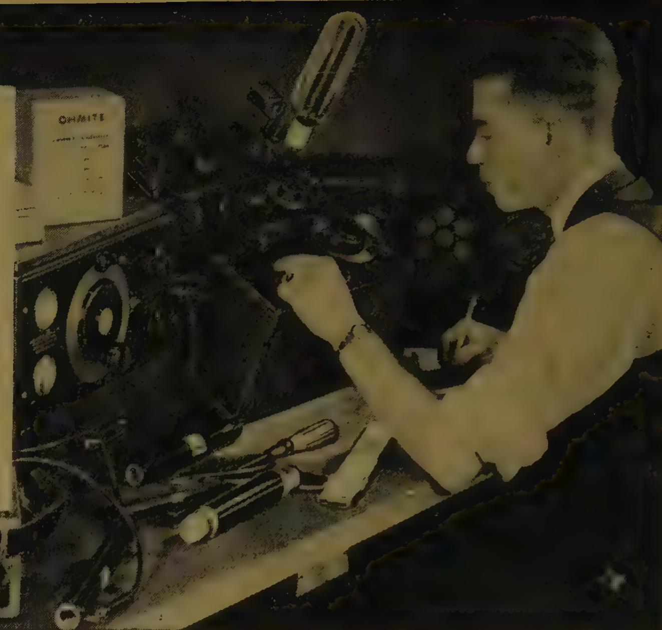
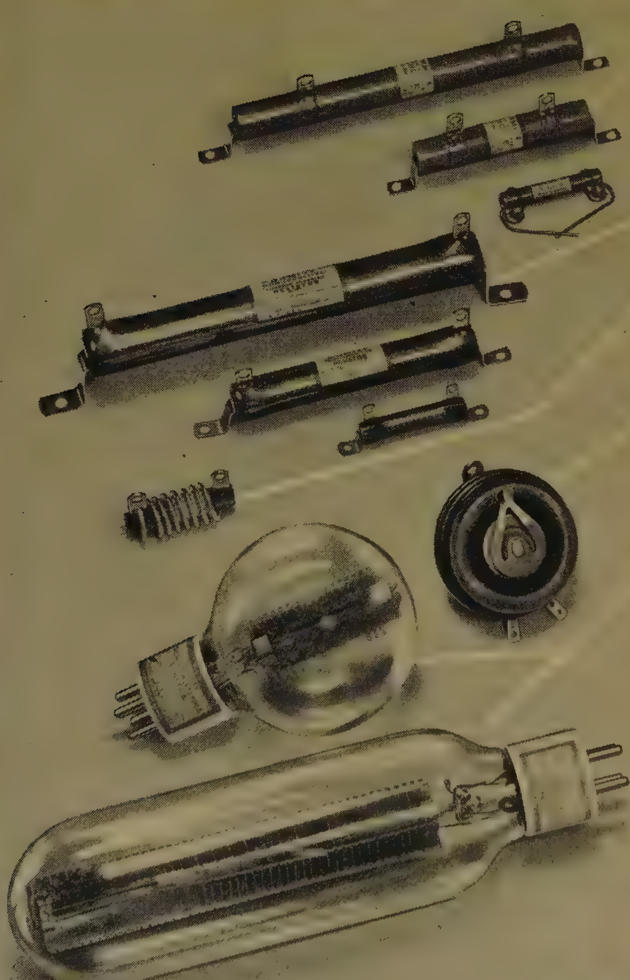
CD 47 H-11

GENERAL ELECTRIC PLASTICS FACTORIES ARE LOCATED AT SCRANTON, PA., MERIDEN, CONN., COSHOCTON, OHIO . . . FORT WAYNE, IND. . . . TAUNTON AND PITTSFIELD, MASS.

OHMITE
Resistors and Chokes
FOR RADIO FREQUENCY APPLICATIONS





R. F. PLATE CHOKES—Single-layer wound on low power-factor steatite core, protected by a moisture-proof coating. Five stock sizes, rated at 1000 M. A., in bands from 2½ to 160 meters.

NON-INDUCTIVE RESISTORS—Vitreous-enameled, wire-wound, power-type resistors for R. F. applications. Provided in 50, 100, and 160-watt sizes. Many resistance values from 5 to 5000 ohms.

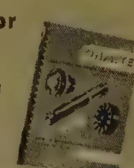
PARASITIC SUPPRESSORS—For the suppression of u.h.f. parasitic oscillations. Consists of a 50-ohm non-inductive resistor and .3 microhenry choke in parallel.

DIRECTION INDICATOR POTENTIOMETER—A compact, low cost unit used in a simple potentiometer circuit with an ordinary 0-1 milliammeter to indicate, remotely, the position of a rotary beam antenna. For complete information, write for Bulletin No. 128.

DUMMY ANTENNAS—Glass sealed, non-inductive, non-capacitive, constant resistance units used to check R. F. power, transmission line losses, and line to antenna impedance match. Made in 100 and 250-watt sizes with various resistances. For complete information, write for Bulletin No. 111.

Write on Company Letterhead for Catalog No. 40

Gives valuable data and information on resistors, rheostats, chokes, tap switches, and other units. Send for your copy.



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Be Right with **OHMITE**

RHEOSTATS • RESISTORS • TAP SWITCHES

Each adaptable to many coil and contact arrangements to fit your individual needs.

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What's the present temperature of that transformer oil? What was the highest temperature reached since last reading?

You want the answers to both these questions—and the MAX-MIN gives them ... accurately!

The red index pointer on the MAX-MIN is manually set to either the low or high side of the main indicating pointer. When set on the high side, for example, it moves as the temperature increases, always remaining at the extreme temperature reached, until manually re-set. Thus in one quick reading you get both *present* temperature and the *peak* temperature since last reading.

For complete details see your jobber or local Weston representative. Weston Electrical Instrument Corporation, 664 Frelinghuysen Avenue, Newark 5, New Jersey.

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POWER FACTOR CORRECTION CAPACITORS

YOU'LL SAVE ON POWER BILLS AND AUTOMATICALLY GET:

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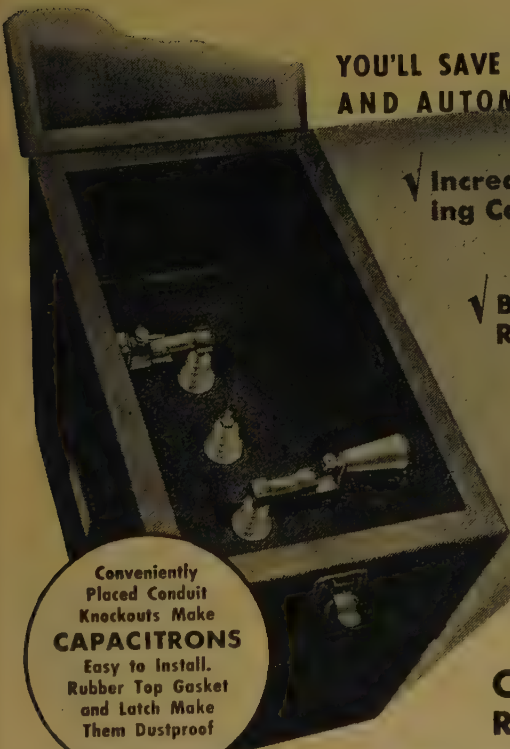
√ Better Voltage Regulation...

√ Reduced Power Losses.....



Conveniently Placed Conduit Knockouts Make CAPACITRONS Easy to Install. Rubber Top Gasket and Latch Make Them Dustproof

Multi-Cell Construction with Famous "TORRIDOL" Impregnant Means Assured Dependability for Every Installation

The flexibility of Capacitron's *Multi-Cell* design provides an exactly correct capacity for every load requirement. "Torridol", the amazing capacitor oil that resists temperatures up to 600° F. without chemical change or decomposition, maintains one of the most effective safety factors ever developed against overloads. Thousands of "Torridol" units for Power Factor Correction are in use throughout the world. They have proved their ability to provide efficient, trouble-free service and a highly profitable investment to their owners.

CAPACITRONS are Available in a Wide Range of Standard and Special Ratings

After hermetic sealing, Capacitron *Multi-Cells* go through 11 separate and rigorous performance tests before they take their place with others to make up complete Capacitron *Multi-Cell* Power Factor Correction units! Low voltage, 60 cycle; 1, 2 and 3 phase units are furnished in standard ratings of .5, 1, 2.5, 5, 7.5, 10 and 15 KVA for installation directly on the equipment or close by. 230 volt models come in sizes from .5 to 10 KVA. 460 and 575 volt units range from .5 to 15 KVA. Several units may be shunted to give greater total capacity. All may be used on lower frequencies with reduced KVA ratings. Automatic voltage discharge conforms with N.E.C. specifications.

While we recommend the use of low voltage capacitors wherever possible, we are in a position to supply Capacitrons in various sizes having ratings of 2,300, 4,000, 4,600, 6,900, 7,620, 11,950 and 13,200 volts.

Advise us of your requirements. We make prompt delivery on standard units. Special consideration given to ratings other than standard.

The CAPACITRON *Company*

849 N. KEDZIE AVENUE
CHICAGO 51, ILLINOIS
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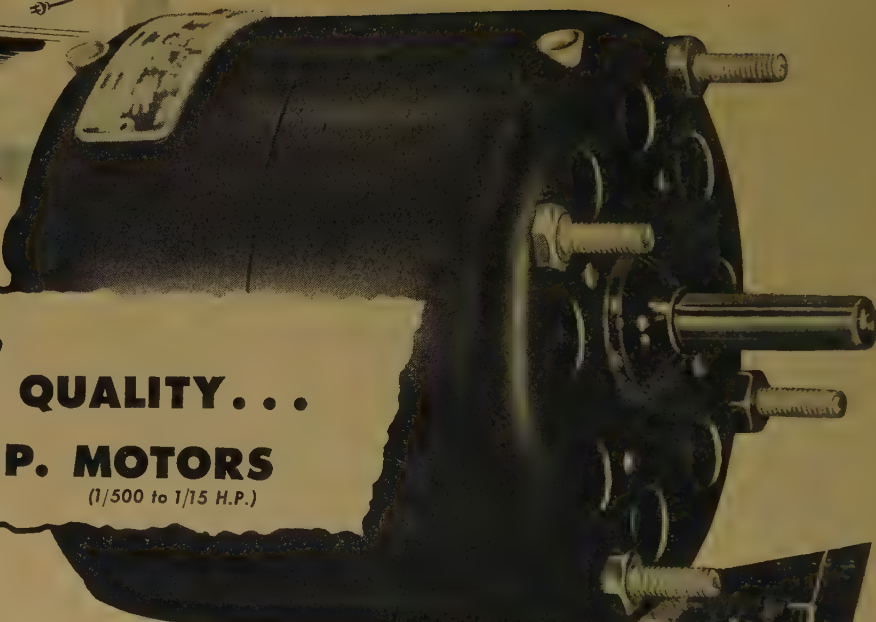
CAPACITRONS—The Result of 17 Years in Capacitor Manufacturing

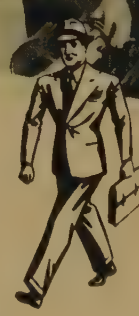
For a quality product that sells...



USE FASCO QUALITY... FRACTIONAL H.P. MOTORS

(1/500 to 1/15 H.P.)

Product sales trouble may be averted ... by applying FASCO *experienced* F.H.P. motor engineering and production know-how ... to eliminate motor trouble *before* it starts. A skilled, *experienced* FASCO factory engineer will meet with you in your own plant ... engineer the electrical and physical characteristics of the motor you need ... and adapt a *standard* motor to your product's *special* requirements. For superior product sales advantages, consult with us NOW, if your plans call for production-run quantities of small motors (1/500 to 1/15 H.P.) or blowers.



... Use our Direct Factory Representation by Experienced Fractional H. P. Engineers

Pilot Fractional H.P. MOTORS & BLOWERS — A PRODUCT OF FASCO

F. A. SMITH MANUFACTURING CO., INC.
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VITAMIN Q DIELECTRIC
HAS PERMITTED SUBSTANTIAL RE-DUCTIONS IN BOTH THE SIZE AND WEIGHT OF MANY OIL-FILLED CAPACITOR TYPES
TYPICAL! Compact Capacitors for Photoflash and Energy Storage Uses
Sprague Capacitors with Vitamin Q dielectric have led in establishing new standards of compactness, light weight and dependability for electric flash tube (photoflash) photography. Also, they assure outstanding economies and greater efficiency for flash welding and time control circuits where duty cycles other than those used in photoflash work prevail. Write for Sprague Engineering Data Bulletin No. 3205.
SPRAGUE ELECTRIC COMPANY, North Adams, Mass.
PIONEERS OF ELECTRIC AND ELECTRONIC PROGRESS

BURNDY Terminals

— Available in a wide variety of types to meet all needs. All provide connections *high* in mechanical strength and electrical efficiency. Write for catalog.

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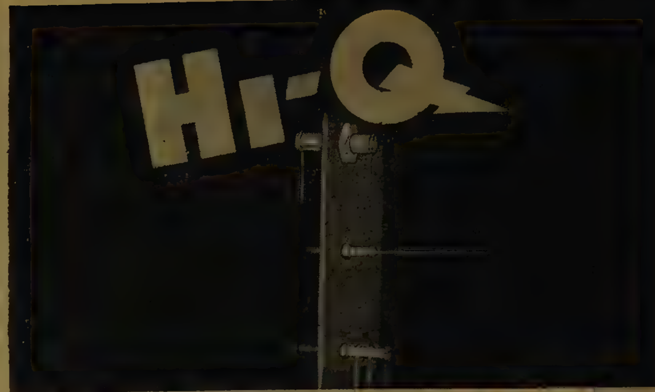
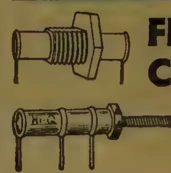
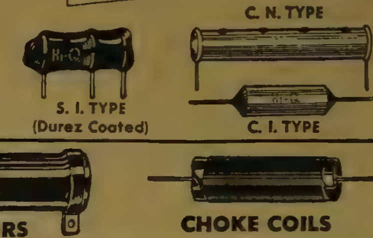




FEED-THRU and STAND-OFF CERAMIC CAPACITORS

are made to the same high performance standards as conventional CN and CI type Hi-Q capacitors. Engineers who have thoroly investigated Hi-Q capacitor performance are unanimous in their approval. We invite inquiries for samples to meet the exact needs of your applications.

OTHER Hi-Q COMPONENTS



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FRANKLINVILLE, N. Y.

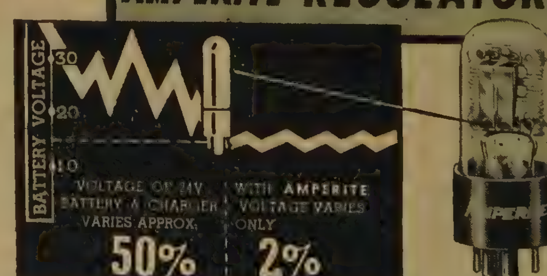
THERMOSTATIC METAL TYPE DELAY RELAYS

PROVIDE DELAYS RANGING FROM 1 TO 120 SECONDS

FEATURES: — Compensated for ambient temperature changes from —40° to 110° F . . . Hermetically sealed; not affected by altitude, moisture or other climate changes . . . Explosion-proof . . . Octal radio base . . . Compact, light, rugged, inexpensive . . . Circuits available: SPST Normally Open; SPST Normally Closed.

PROBLEM? Send for *"Special Problem Sheet"*

AMPERITE REGULATORS



Amperite REGULATORS are the simplest, lightest, cheapest, and most compact method of obtaining current or voltage regulation . . . For currents of .060 to 8.0 Amps . . . Hermetically sealed; not affected by altitude, ambient temperature, humidity. *Write for 4-page Illustrated Bulletin*

AMPERITE CO., 561 Broadway, New York 12, N. Y.
In Canada: Atlas Radio Corp., Ltd., 560 King St., W. Toronto

HIGH VOLTAGE; NO DANGER

Portable-Rugged-Safe!

DU MONT Type 263-A
HIGH-VOLTAGE POWER SUPPLY

High voltage is the keynote of modern oscillography. Especially for brilliant traces at ultra-high speeds.

Type 263-A High-Voltage Power Supply was designed with present and future needs in mind. It provides a dependable yet inexpensive power supply for modernizing and extending the usefulness of certain types of cathode-ray oscillographs when examination of extremely high writing rates is required.

So here's a complete high-voltage power supply. Suitable for any application where high voltage at low current is called for. Consists of radio-frequency oscillator with its own power supply, an r.f. step-up transformer, a half-wave rectifier, and a high-voltage filtering and metering system.

Compact. Light. So designed that inexperienced personnel may handle it with safety. And it is made still safer in case of accidental contact with high voltage, because very little power is stored in its filtering circuit. Furthermore, no equipment damage will result if output is short-circuited. Rugged mechanical construction permits field or laboratory use.

Surely Type 263-A is a "must" instrument whether for high-voltage oscillography or general use!

Details on request!

Salient Oscillographic Features . . .

- ✔ 10,000 volt intensifier potential available for use with cathode-ray oscillographs.
- ✔ Visual observation of single transients hitherto invisible.
- ✔ Photography of extremely high writing rates (for example, 2000 km./sec. on 5RP11 at 10 kilovolts).
- ✔ Observation of entire waveshapes of short duration on long persistence screens.
- ✔ Convenient use with Type 5RP-A Multi-band High-voltage Cathode-ray Tube.

Working Details . . .

- ✔ Continuously variable d-c output from 5,000 to 10,000 volts with loads up to 200 microamperes.
- ✔ Regulation within 20% from no load to 200 microampere load.
- ✔ Ripple voltage on output less than 0.5%.
- ✔ Power supply: 115 volts, 50-60 cps.
- ✔ Power consumption: 100 watts.
- ✔ Dimensions: 10⅞" h. x 8⅛" w. x 14¾" d.
- ✔ Weight: 24 pounds.

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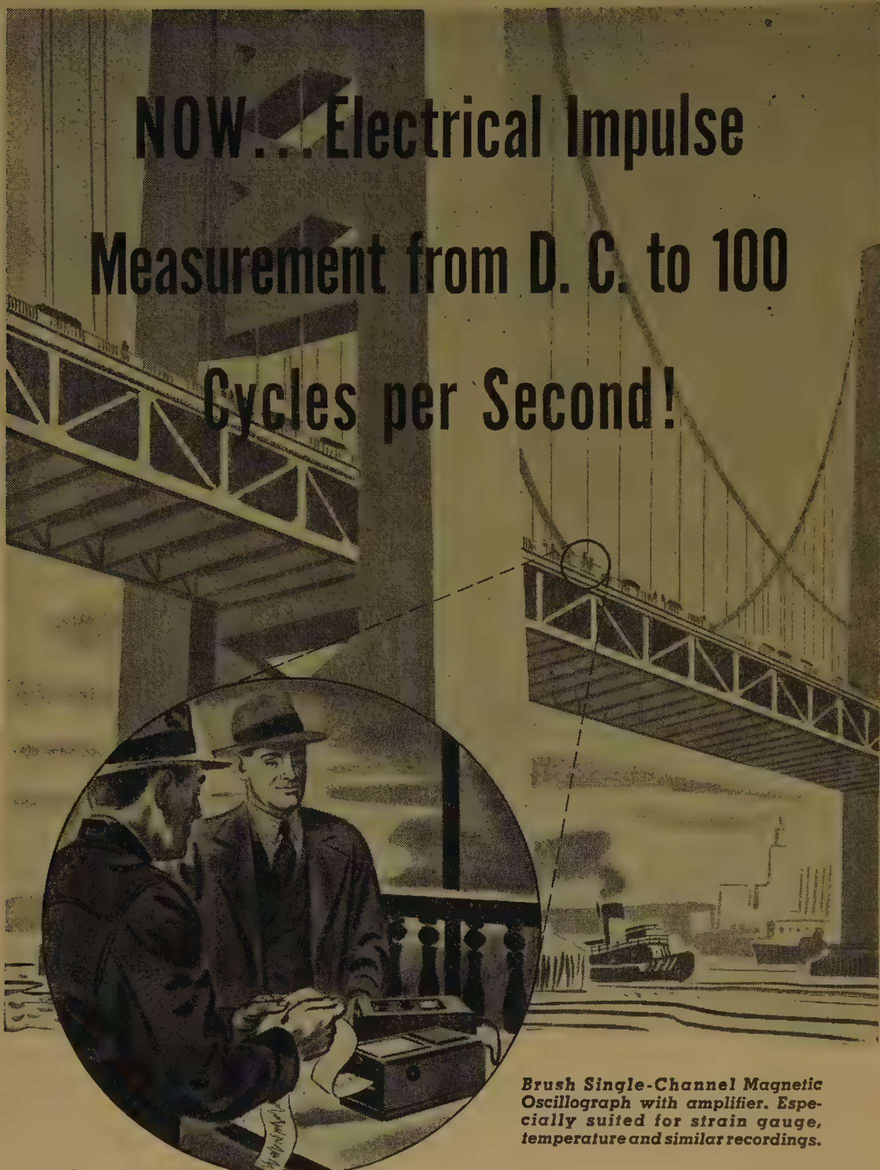
DUMONT *Precision Electronics & Television*

ALLEN B. DUMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: ALBEEDU, PASSAIC, N. J., U. S. A.

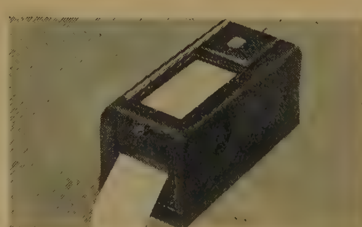
NOW...Electrical Impulse Measurement from D. C. to 100 Cycles per Second!



Brush Single-Channel Magnetic Oscillograph with amplifier. Especially suited for strain gauge, temperature and similar recordings.

Brush Oscillographs make direct-inking recordings

Brush Magnetic Oscillographs may be used for making detailed recordings of electrical impulses for an almost limitless number of applications. The Magnetic Pen Motor is capable of recording a D.C. signal. Used with the BL-905 amplifier, the frequency range is from .2 to 100 cycles per second. Recordings are direct, instantaneous, ink-on-paper graphs. Can be used for recording strains, pressures, vibrations, temperatures, light intensity and countless other phenomena.



Brush Double-Channel Magnetic Oscillographs for use where two simultaneous recordings are desired—as in synchronizing problems.

Write today for detailed bulletin.

The BRUSH Development Company

3421 PERKINS AVENUE • CLEVELAND 14, OHIO

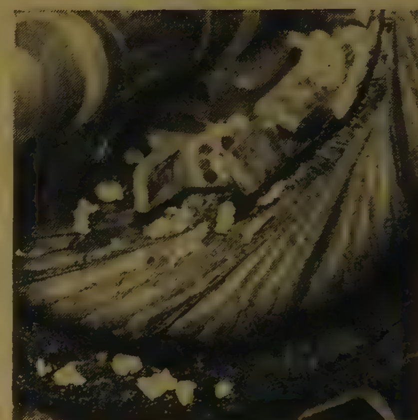
Canadian Representatives:

A. C. Wickman (Canada) Ltd., P. O. Box 9, Station N, Toronto 14

Silicone News

DC SILICONES

DC Silicone Insulation Stands Up *WHILE ALUMINUM MELTS!*



It's hard to believe even when you see it. Note melted metal. Yet windings keep "infinite resistance" at 500 volts!

This *kind* of performance proves again the real economy of DC Silicone Insulation.

Silicone Insulation will frequently stand more heat and moisture than the metals used in building motors. We've proved it in a laboratory way many times, but even our own chief electrician was skeptical until . . .

A fan-cooled 15 H.P. (1730 r.p.m., 3-phase, 440 volt, 60 cycle) Silicone-insulated motor was used to replace a similar 20 H.P. Class "B" motor driving our water tower pump. The actual overload was small, but after a few months the fan was removed for repair, and somebody forgot to replace it. Three weeks later the motor was turned off because it sounded as though a bearing was shot. One was—and aluminum from the rotor had melted and splattered over the windings. Aluminum melts at 1220° F., but the Silicone-insulated winding still had "infinite" resistance to ground when "Megged" at 500 volts.

This incident may never be duplicated in your plant, but the heat (and moisture) resistance of DC Silicone Insulation means at least ten times longer life for Silicone-insulated motors in ordinary service. It makes smaller motors do bigger jobs. It is reducing the cost of motor maintenance in many different industries. Try Silicone Insulation (DC 996 plus glass and mica) on *your* toughest motor job. For additional information about DC 996, send for leaflet No. A 3-8.

DOW CORNING CORPORATION
MIDLAND, MICHIGAN

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In Canada: Fiberglas Canada, Ltd., Toronto
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Dow Corning
FIRST IN SILICONES

It's NOT the HEAT nor the HUMIDITY

IT'S THE INSULATION that counts in hot-spot wiring

100° in the shade is a cold-wave compared to the baking heat of boilers, steam lines and ash pits. Add rotting fumes and your circuits are building up trouble unless the wire is made to take it — with Rockbestos A.V.C., the *permanent insulation*.

Failure-creating heating and cooling cycles in ducts or conduit runs won't present any problems either, if they are wired with Rockbestos A.V.C. wires and cables. Their felted asbestos insulation, impregnated with heat, flame and moisture resisting compounds, withstands temperatures up to 230° F. and condensation without baking brittle, drying out, cracking, flowing or failing. And you get extras in protection from swelling, rotting or burning if circuits are exposed to fumes, oil, grease or flame.

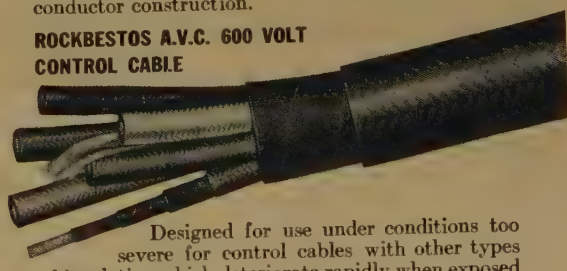
The two Rockbestos constructions pictured are among 125 standard types — including Switchboard Wires, Multi-conductor Power Cables, Secondary Network and Fireproof Vault Cable and Rockbestos All-Asbestos Wires and Cables. Write for a catalog.

ROCKBESTOS PRODUCTS CORPORATION
213 Nicoll St., New Haven 4, Conn.

ROCKBESTOS A.V.C. 600 VOLT POWER CABLE—TYPE AVA

For power and lighting circuits installed in conduit or exposed to high ambient temperatures and condensation. Impregnated asbestos insulation and braid won't bake dry, flow or de-center under operating temperatures up to 230° F., and won't rot or bloom when exposed to corrosive fumes, oil or grease. Sizes No. 18 AWG to 2,000 MCM. Similarly insulated cables up to 5,000 volt rating, plain, lead-sheathed or armored, in single and multi-conductor construction.

ROCKBESTOS A.V.C. 600 VOLT CONTROL CABLE



Designed for use under conditions too severe for control cables with other types of insulation which deteriorate rapidly when exposed to high temperatures. It will operate successfully under the attack of heat, oil, grease or corrosive fumes, will not burn, and is suitable for installation either open or in conduit as it has ample moisture resistance. In one to 19 conductors, standard stranding AWG No. 9—19/#22 and No. 12—19/#25. Other strandings available to customer's specification.

125 different wires, cables and cords have been developed by Rockbestos to meet severe or unusual operating conditions.

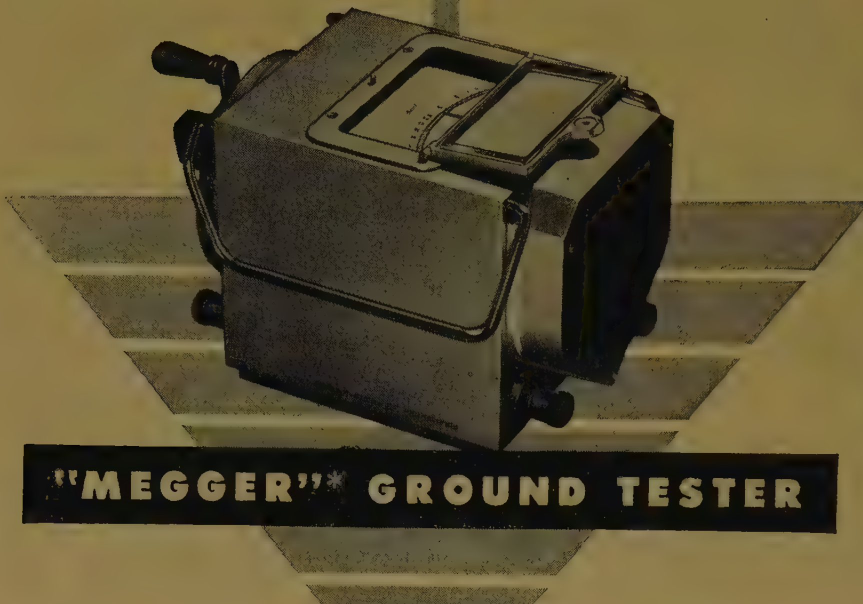
ROCKBESTOS A.V.C.

The Wire with Permanent Insulation

PERMANENTLY INSULATED ROCKBESTOS WIRES AND CABLES

NEW YORK BUFFALO CLEVELAND DETROIT CHICAGO ST. LOUIS LOS ANGELES PITTSBURGH SAN FRANCISCO SEATTLE PORTLAND, ORE.

For BETTER *and* SAFER GROUNDING



For measuring resistance to earth of man-made ground connections, used with generating stations, substations, transmission towers, lightning arresters and machine frames. Grounding for protection . . . for insurance.

Check **THESE FEATURES** to see *why* the "Megger" Ground Tester is used for ground resistance measurements . . . and *how* it can do a job for you.

- Has its own hand generator; requires no batteries or other external power supply.
- Direct-reading in ohms—"Like a voltmeter."
- No calculations required.
- Only one set of connections.
- No adjustments or "balancing."
- Self-contained, rugged and portable.
- Unaffected by the exact resistance of the reference grounds.
- Unaffected by stray current in the earth either a-c or d-c, or by polarization or electrolysis.
- Covers a wide range of resistance—0-3 up to 0-30,000 ohms.
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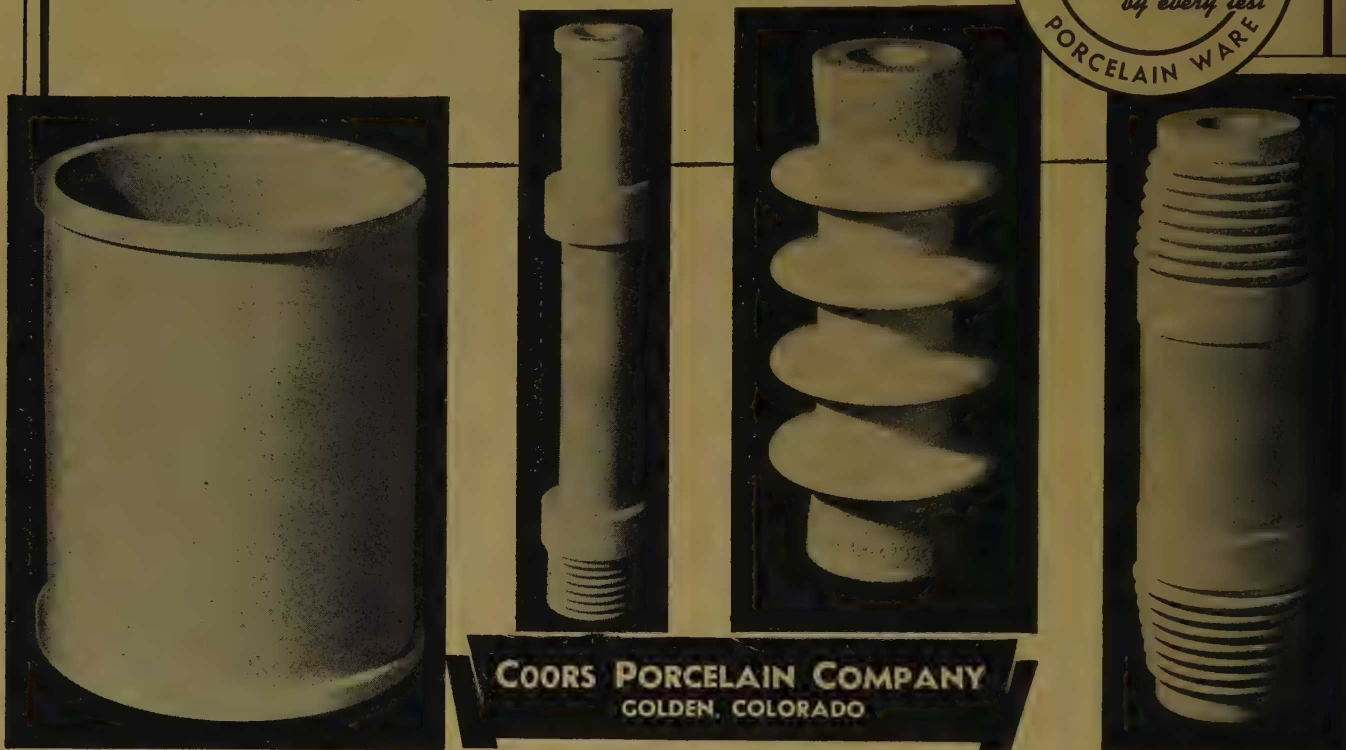

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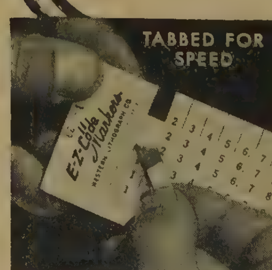

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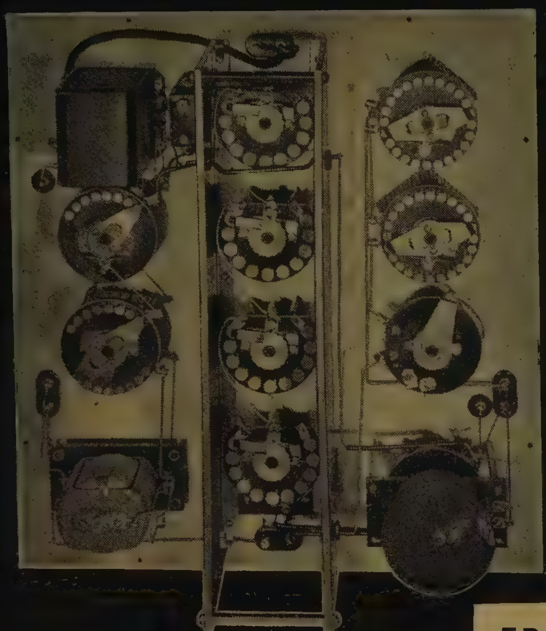

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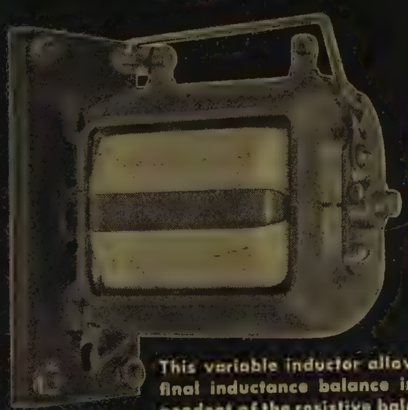

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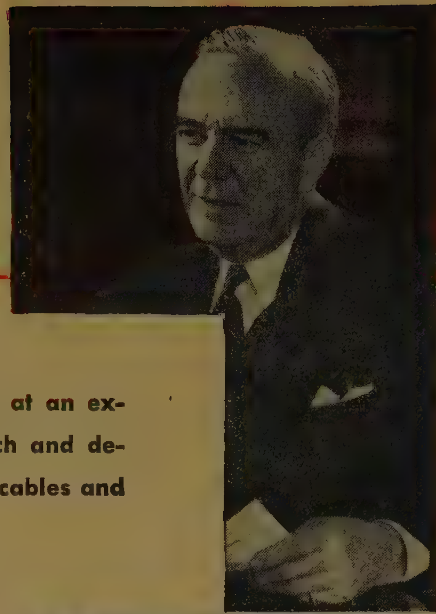

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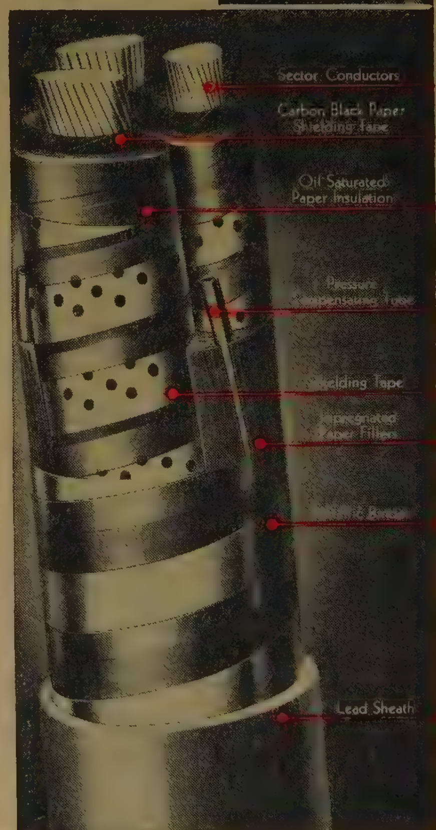

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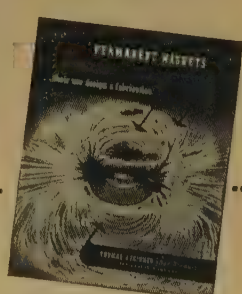

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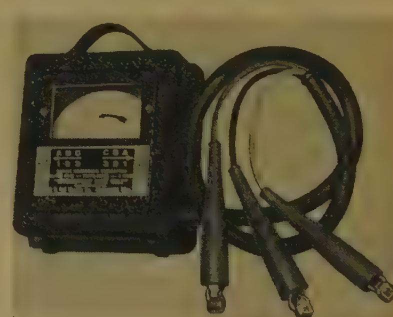

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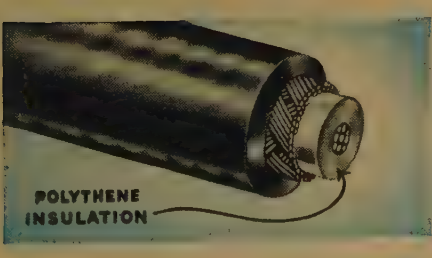

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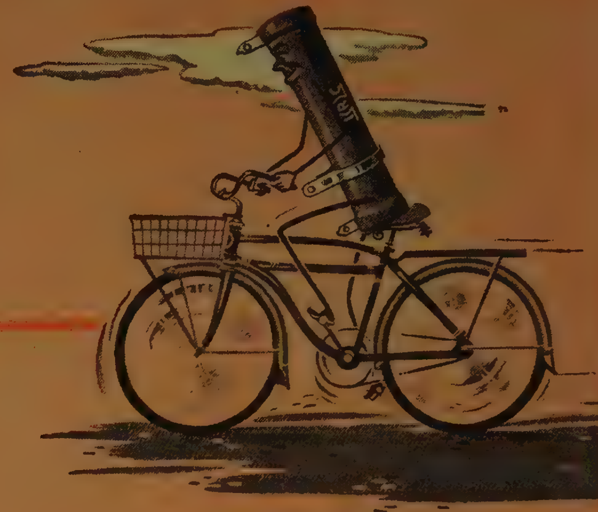

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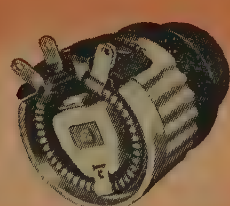

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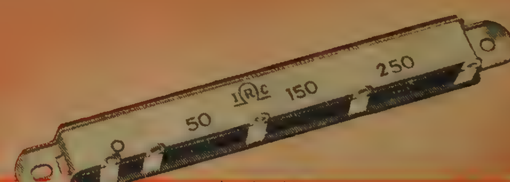

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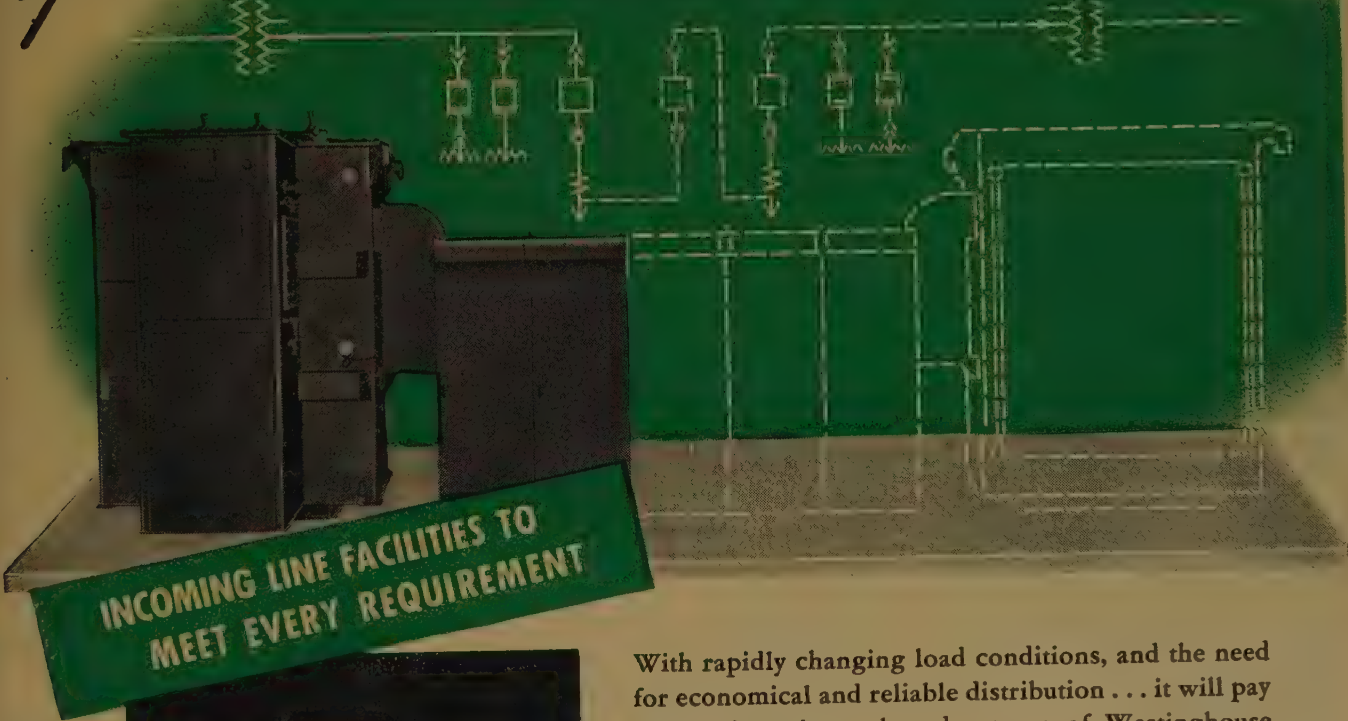
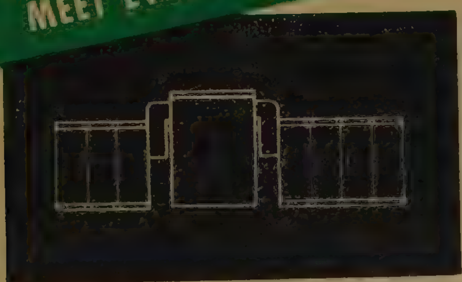
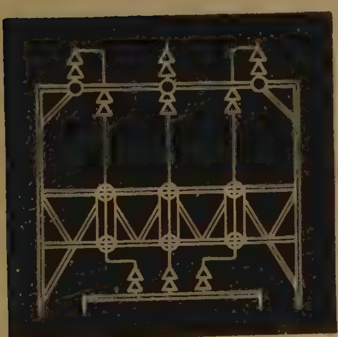
WESTINGHOUSE UNIT SUBSTATIONS





When required, Unit Substations can be supplied with co-ordinated, metal-clad, "Unitized" switchgear for incoming power supplies of 13,800 volts and below.



Prefabricated, overhead, incoming line structures.

Transformer-mounted terminal chambers or switches for use with underground cables.

With rapidly changing load conditions, and the need for economical and reliable distribution . . . it will pay you to investigate the advantages of Westinghouse Unit Substations.

They not only meet today's demands, but provide *flexibility* for future changes. Increased load requirements or changes in the center of loads are easily accommodated. Co-ordinated design plus "Unitized" switchgear permits selecting unit capacities to meet existing needs, yet simplifies expansion as exemplified above. Compactness provides application flexibility—lower real estate costs—pleasing appearance—and greater accessibility. Unit Substations can be located close to the load center. When the load center shifts, they can be easily moved to the new location.

Westinghouse Unit Substations are today's answer to the fast growing loads ahead. For full information, call Westinghouse or write for B-3238, Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa.

J-97125

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UNIT SUBSTATIONS FOR ANY SYSTEM

Waldes TRUARC retaining rings

2 MINUTES vs. 2 SECONDS!

This skilled assembler is using a screwdriver and six screws to install a collar. Each of the many light streaks indicate another time-consuming arm-motion, with less efficiency and greater fatigue.

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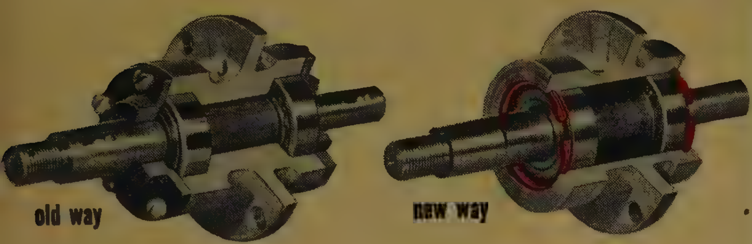
Right before your eyes is visual proof of how much assembly time can be cut. It's done simply by replacing conventional fastening devices with Waldes Truarc Retaining Rings. Less time is required for job-training, because Truarc guarantees accurate relationship of parts independent of the skill of the assembler. Inspection is simplified, rejections reduced—and the product will function longer without repair.

This new fastening does wonders for machine design. Truarc rings mean lighter weight, less bulk, maintenance of tolerances. Production and maintenance men find Truarc cuts labor and material costs wherever used. Its unique taper design assures constant circularity. Its never-failing grip assures a better job of holding machine parts together. Yet Truarc rings are easily removed and re-installed in a few seconds.

slash assembly time, cut costs

Typical cost-cutting applications:



TRUARC TRIMS 13 MINUTES' MACHINING TO 6

Permits redesign of exhaust-fan bearing-housing for M. & E. Manufacturing Company, Indianapolis. Truarc cuts assembly time 66%, trims 25% off weight of unit, lowers labor and material costs.

TRUARC ELIMINATES 12 OPERATIONS, CUTS UNIT COST 65 CENTS

Changeover to Truarc in hydraulic Powerpak cuts assembly time over 50% for Electrol, Inc., Kingston, N. Y. Permits use of semi-skilled assemblers, cuts maintenance time more than half.

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THERE ARE DIFFERENT TRUARC RINGS FOR ANY APPLICATION:

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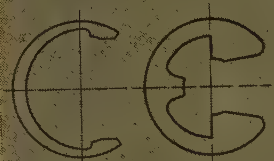
BEVELED* and BOWED.* Absorb end-play rigidly or resiliently where tolerances accumulate.



CRESCENT and E-RING. Snap on radially where axial assembly is impossible. Give firm grip.

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*Available for both external and internal applications.

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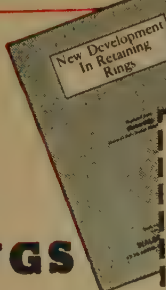

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Ranges: .015, .05, .15, .5, 1.5, 5, 15, 50, 150, 500 *microamps full scale.*

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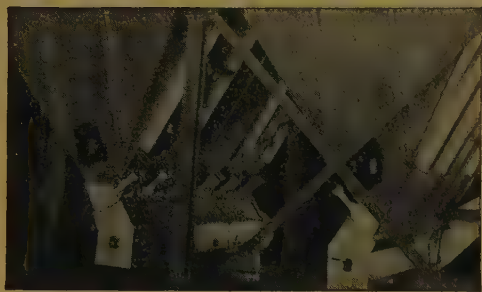

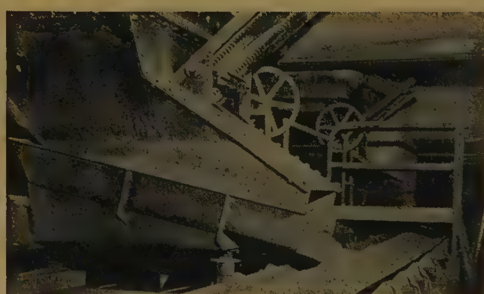

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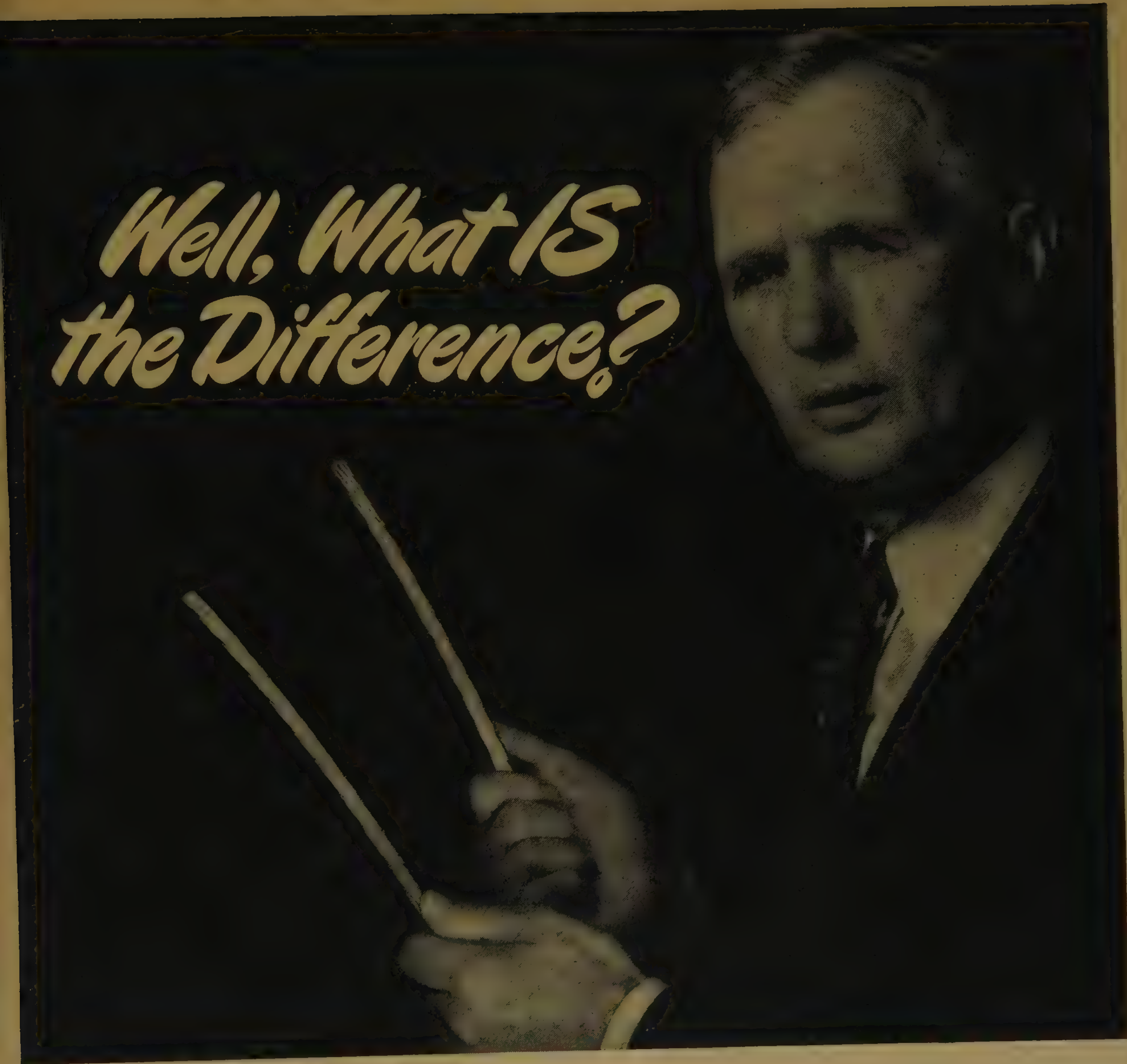
Interested persons should write the Personnel Department, Tennessee Valley Authority, Knoxville, Tennessee.



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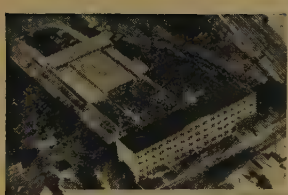

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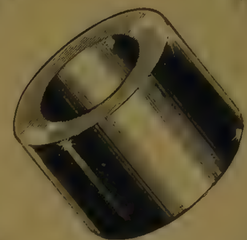

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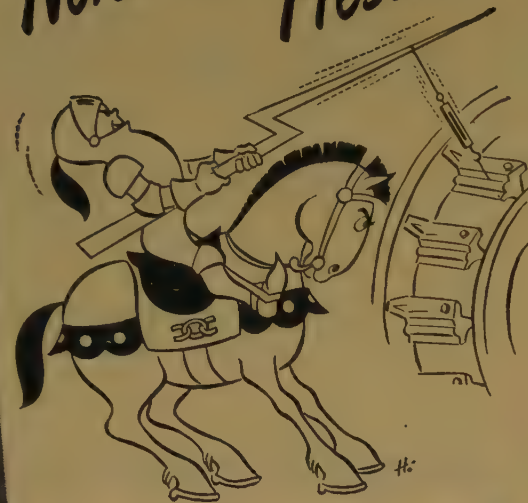
on better brush performance —

No. 2-Spring Pressure



The desirability of correct and uniform brush pressure cannot be disputed. When it isn't possible to adjust the tension to the exact value prescribed, adjust to a point which is slightly above rather than below the recommended pressure. Occasionally the operator may find the pressure for best results to be somewhat greater or less than the manufacturer's recommendation. Above all, uniform pressures are most important. Morganite quality control guarantees uniformity of material — a combination of the two assures satisfaction.

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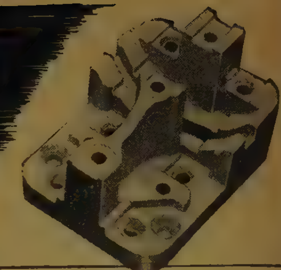

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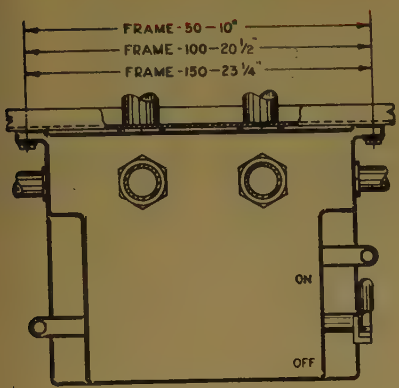
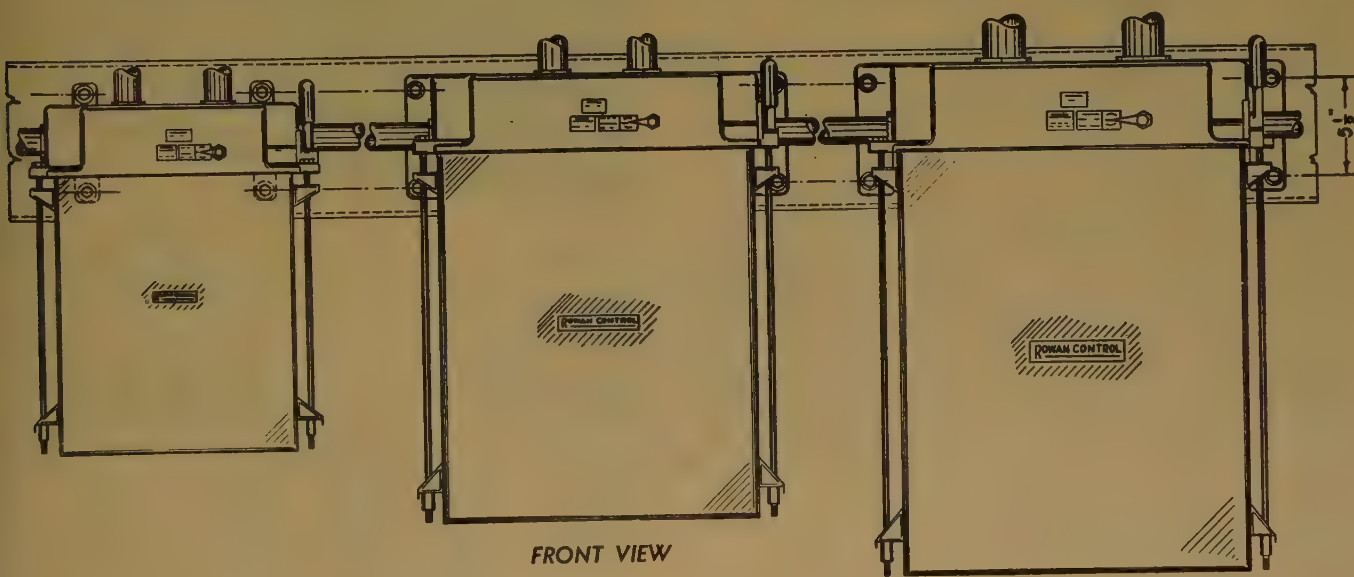
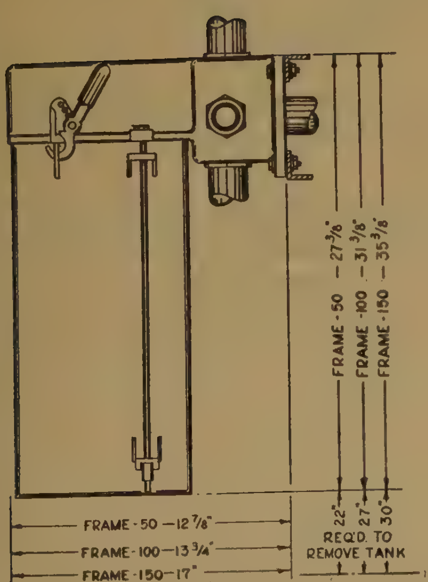


TOP VIEW



FRONT VIEW



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For complete information, call in the Rowan representative in your area.

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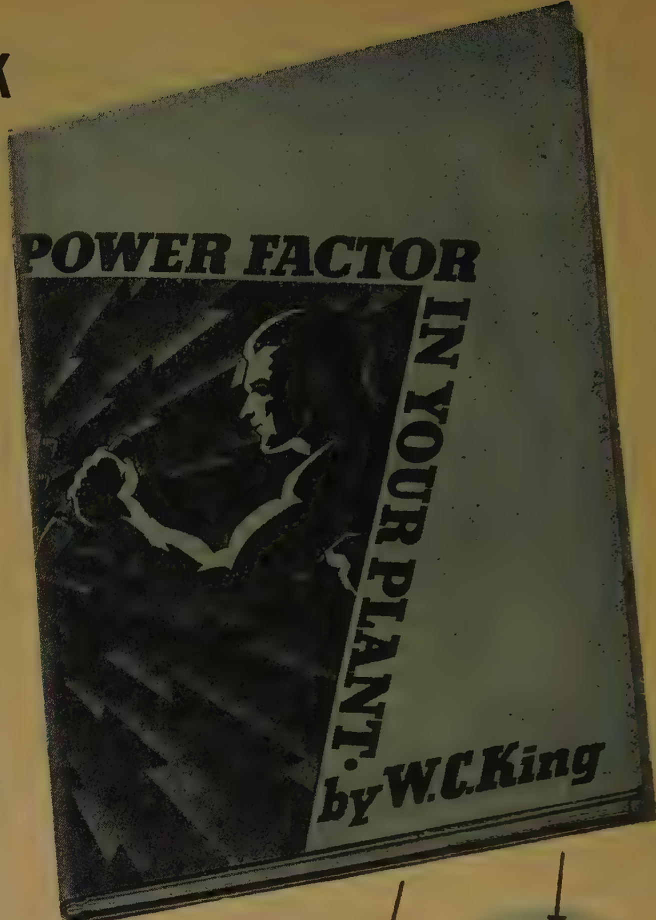
THE ANSWER BOOK ON POWER FACTOR CORRECTION



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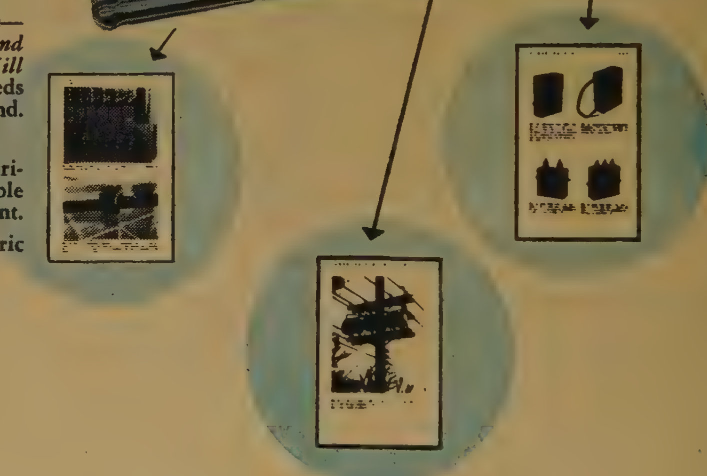

TYPICAL CHAPTER HEADINGS

- What Is This Thing Called Power Factor?
- What Effect Does Poor Power Factor Have On Electrical Equipment?
- How Do I Figure The Amount of Power Factor Improvement I Need?
- How Do I Determine the Power Factor in My Plant?
- Does Poor Power Factor Increase My Losses Very Much?
- What Effect Does Power Factor Have on Voltage Drop?
- When Should I Consider a Synchronous Motor Drive?
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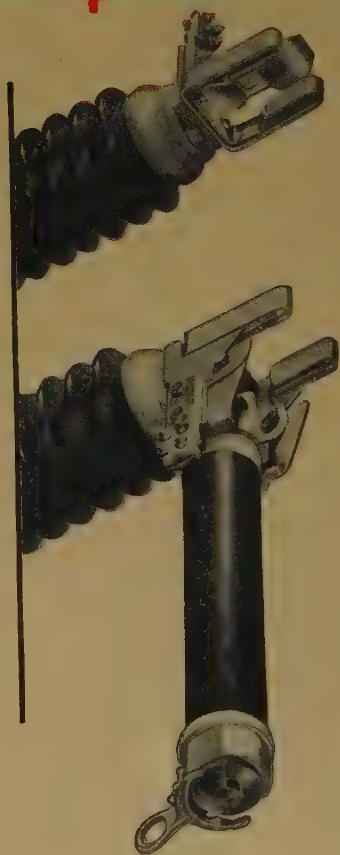

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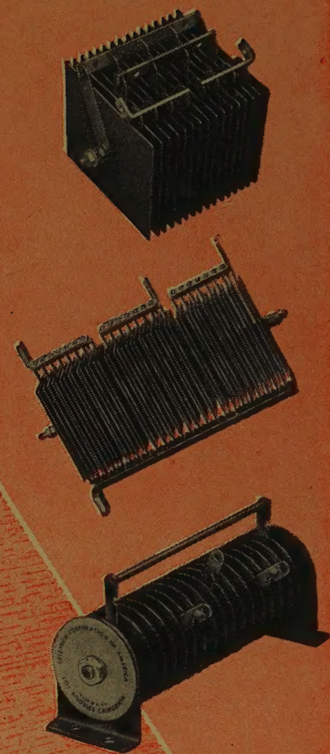

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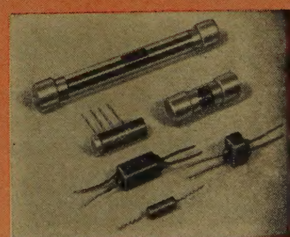
SCA Selenium Pyramid reflects all the durability of the ancient Egyptian pyramids. Selenium Rectifiers are ENGINEERED FOR ENGINEERS. Improved performance at lower costs through ENGINEERED adaptability. Selenium Corporation of America meets exacting specifications of modern electronic developments. Manufacturers of a broad line of Selenium Power and Instrument Rectifiers, Self generating Photo-Electric Cells and allied scientific products.

Selenium Rectifiers are rapidly becoming standard in industry for all rectifier applications. Selenium Corporation of America's engineering experience can be called upon for the development and production of special rectifiers for any application.

CHECK THESE OUTSTANDING FEATURES

- ✔ Permanent characteristics
- ✔ Adaptability to all types of circuits and loads
- ✔ Unlimited life—no moving parts
- ✔ Immunity to atmospheric changes
- ✔ High efficiency per unit weight
- ✔ From 1 volt to 50,000 volts rms.
- ✔ From 10 micro-amperes to 10,000 amperes
- ✔ Economical — simple to install — no maintenance cost
- ✔ Hermetically sealed units available



INSTRUMENT RECTIFIERS

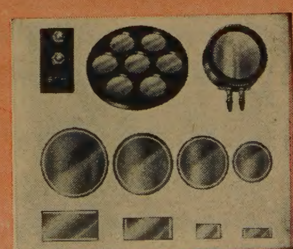


PHOTO-ELECTRIC CELLS

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SELENIUM CORPORATION OF AMERICA

Affiliate of VICKERS Incorporated

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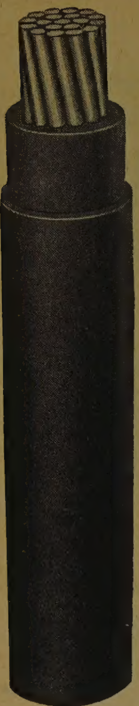

Anhydroprene

HAS no BRAIDS TO ROT!

ANHYDROPRENE wires and cables are made with a thin wall of neoprene instead of a fibrous braid. There is no braid to rot or to "freeze" to the wall of a duct. The thin neoprene jacket resists oils and solvents as well as acids, alkalies and corrosive chemicals.

Anhydroprene wires can be installed overhead in messenger rings. They can be racked on the wall or they can be installed in conduits or raceways. Underground they can be used in ducts.

Simplex Data Sheet #115 has complete information on this type of wire. Write for it today.

Simplex Wire & Cable Co.
79 Sidney Street, Cambridge, Mass.

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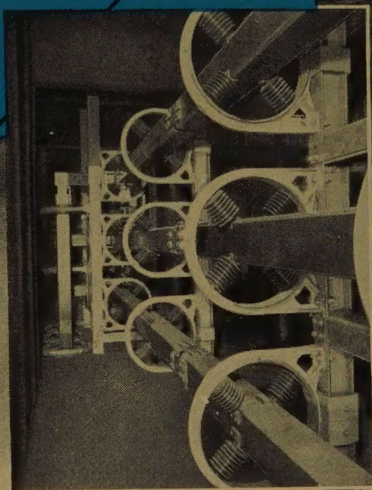
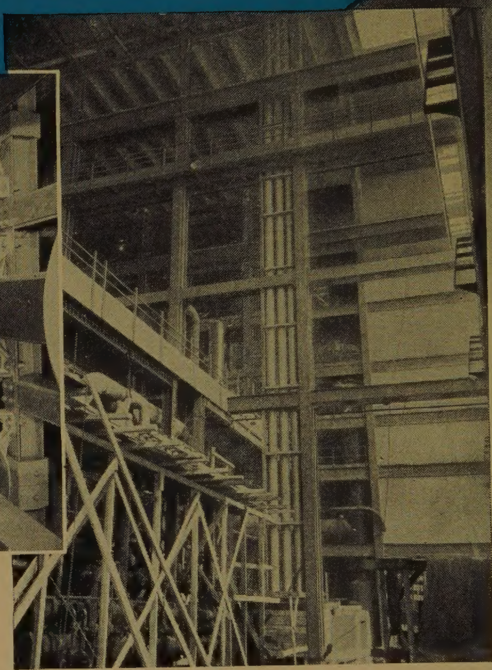
THIS IS *Isolated* PHASE BUS



Housing has not yet been added here—installation is progressing along with construction of a new plant.



View of 2200 ampere, 4160 volt auxiliary generator leads at Philadelphia Electric's Southwark Station.

. . . *and here's* what it means to *you*

Complete isolation of phases in I-T-E Bus construction offers a high degree of protection against electrical faults and gives you greater continuity of service in power plant operation. Here's why—

Each conductor is enclosed in an individual non-magnetic metal housing and the housings are separated by a protective insulating air space. This practically eliminates phase-to-phase short circuits and greatly reduces the possibility of a fault in any one phase. A copper ground bus is a part of the steel supporting frame and grounds every part of the supporting framework.

And, there are other advantages in using I-T-E Isolated Phase Bus Structures. Dust-proof enclosures give permanently clean interiors. The use of non-organic materials assures permanent dielectric strength. Construction is adaptable for use under all building conditions and, since the bus is factory-made, it can be tailored to meet your requirements.

Complete details are contained in Catalog 10147. Why not write for your copy, now, to I-T-E Circuit Breaker Company, 19th and Hamilton Streets, Philadelphia 30, Pa.

I-T-E *The center of Switchgear Progress*

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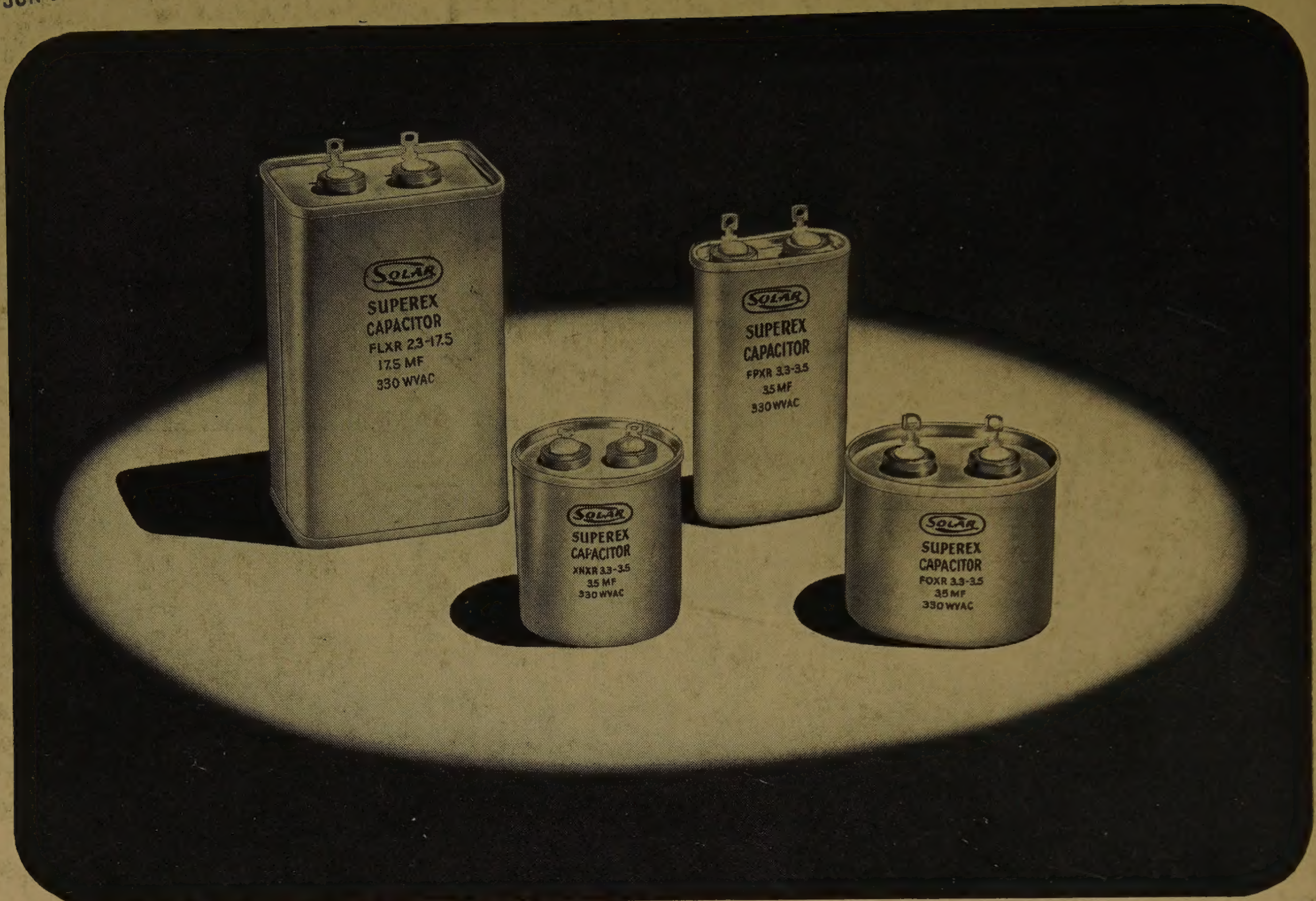

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